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SAVING THE ANIMAL LIFE OF AFRICA—A NEW METHOD AND A LAST CHANCE

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Towards evening, on rising a hill, we were suddenly greeted by a sight which seemed to astonish even the oldest amongst us. The whole plain, as far as the eye could discern, was covered by an enormous mass of buffalo. Our vision, at the very least computation, would certainly extend ten miles, and in the whole of this great space, including about eight miles in width from the bluffs to the river bank, there was apparently no vista in the incalculable multitude. It was truly a sight that would have excited even the dullest mind to enthusiasm.

So wrote John Townsend of Philadelphia of the plains of the United States in 1834. Today the buffalo on the whole continent number but a few thousand. In all the history of pioneering, there is no more striking example of the horrible effect of combined blood-lust and modern firearms. Before 1834, the senseless slaughter had already begun. Huge numbers of buffalo were shot, Townsend tells us, "merely for the tongues, or for practice with the rifle," and ton after ton of "delicious and savory flesh, which would delight the eyes, and gladden the heart of any epicure in Christendom, was left neglected where it fell, to feed the ravenous maw of the wild prairie wolf, and minister to the excesses of the unclean birds of the wilderness . . . . but when are men economical, unless compelled to be so by necessity?"

From the early nineteenth century, in all parts of the world, the pioneer and the modern firearm began their most deadly work. The "acres of golden plover" are gone. Lucky is the man who sees one of these birds in a season. The great flocks of Carolina paroquets, green and yellow masses wheeling and gleaming in the sunlight, are no more. The bird is extinct. The pronghorn antelope, of which multitudes once

gave life to our plains, has passed away, except for a few thousands The myriads of prairie hens which could once be seen on the great plains are decimated. Of the heath hen, forty living birds remain! Of the flocks of passenger pigeons that used actually to darken the sky all day, not one bird now exists alive. The sea otter is nearly extinct. The story of "The last of the whales" will soon be written. They have retreated to the polar regions, and even there man is exterminating them. In the last century alone, about two dozen species of birds disappeared. It is unnecessary to add to the list of atrocities.

Fortunately, this orgy of killing among the pioneers gave place, in the United States, to a sudden painful awakening and a period of self-control. President Roosevelt led the forces of moderation for a short period. He created many reservations both for mammals and for birds. But even these have been destroyed, in some cases, by the politicians and the forces of wastefulness and disorder. Thus, the bird marsh sanctuaries which President Roosevelt created in Oregon at Lower Klamath Lake and nearby have been drained. Millions of breeding wild fowl have died there, and now—oh beautiful irony—the drained land is found to be useless for cultivation! Nevertheless, conservation has made its gains in America since a century ago, for, as Mr. Townsend wrote in 1834, men can be economical, though only when "compelled to be so by necessity."

It is safe to say, nevertheless, that the early settlement of the United States was accompanied by three high crimes, bad faith in dealings with the natives, waste of the forests, and waste of animal life. Africa is the continent where many of the larger mammals are making their last stand. Is history repeating itself in Africa? Treatment of the natives has unquestionably improved under the Mandate System of the League of Nations.[1] There is little danger of forest destruction, first because the African forests are limited in area, but chiefly because much African timber appears to be of two types—"the kind you can't drive a nail into, and the kind that splits if you do!" But the birds and mammals of Africa are in many cases going the way of their brethren in other lands. It is the same sad story all over again.

If we would realize the desolation which threatens to brood over the African wilderness in a hundred years, we must keep in mind the horrible history of the animal massacres of South Africa. In the beginning of the last century, Gordon Cumming saw in South Africa vast legions of

[1]See "Kenya," by Norman Leys (London, 1924), p. 376, and note. See also Minutes of the Permanent Mandates Commission, 1925.

springbuck streaming through a neck of the hills in unbroken phalanx for two hours. As far as the eye could strain, the landscape was a live with them. In 1830, "what is now the site of Pretoria was inhabited by a number of rhinoceroses."[2] Near Mafeking, zebras and white-tailed gnus literally covered the whole plain. Captain William Cornwallis Harris, at this same period and locality, saw a herd of more than three hundred elephants, so that "the plain looked like one undulating mass." As late as 1860, a native drive of animals in the Orange Free State (instigated by Europeans, and provided, of course, with firearms) collected 25,000 animals of many species, and 6000 were killed at one time! A century ago, the South African plains were "in the literal sense of the word, covered with countless herds of Cape buffaloes, white-tailed gnus, blessbok, bontebok, zebras, quaggas, hill-zebras, hartebeests, eland-antelopes, horse-antelopes, oryx-antelopes, waterbucks, impallah-antelopes, springbucks, and ostriches. Herds of hundreds of elephants were to be seen. Every marsh, every river bed, was literally overcrowded with hippopotami. All other kinds of animals that are now so scarce, such as the large and handsome kudu, and all the different kinds of small wild animals, were to be met with in vast number. About a hundred years ago, the great war of extermination began." The outstanding cause was the improvement in firearms.

"So disappeared from South Africa the gnu, the quagga, [apparently the only species of zebra which gave signs of yielding to domestication] the bontebock, the mountain zebra, the beautiful bluish horse-antelope, the cape buffalo, the elephant, the powerful white rhinoceros, the black rhinoceros, the giraffe, the hippopotamus, and the ostrich. Thirty or forty years ago [1865] these animals were still plentiful; a hundred years ago their number was simply fabulous. They were to the natives of South Africa what the buffaloes were to the American Indians—the chief source of food; and, like the Indians, they used the surplus, but did not eat up or destroy the main supply."

As in America, the slaughter was reserved for "civilized" white men. The white rhinoceros of South Africa is now practically extinct, though so abundant in 1844 that a single trader caused the deaths of thousands by arming four hundred Matabele natives. The last "blaaubok" was killed by the Boers about 1800; the last quagga died in 1880. Like the white rhinos of South Africa, those of the Upper Nile are now doomed, unless the traffic in horns and hides be stopped at once. The South African mountain zebra, bontebok, blessbok and white-tailed

[2] This and other information is from C. G. Schilling's "In Wildest Africa," 1907, and "With Flashlight and Rifle," 1905.

gnu are on the verge of the abyss. Such are the hecatombs of animals knocked into oblivion in a single century by the Boers and the rifle. Perhaps some species will be preserved in small numbers, in a reservation, for a century or even several centuries. But what do a few centuries amount to compared with the aeons of time it must have taken Nature to develop these harmless creatures in their present perfection!

Turning now to what is going on in the rest of Africa today, the picture is almost equally distressing. In 1910, hippopotami were abundant on the Tana River. They have vanished in 15 years! The klipspringers of the Lucania hills have gone since 1905, and the reedbuck with them.

At this very day, the natives of the Belgian Congo are killing elephants for their ivory. As the great tusks become scarcer and more valuable, the pursuit of the last stragglers is redoubling its energy. Although herds of giraffe still flourish in remote districts, yet in the opinion of a naturalist writing in 1907 "this wonderful and harmless animal is being completely annihilated . . . . the day cannot be far distant when the beautiful eyes of the last 'Twigga' will close forever in the desert." The superb and rare sable antelope has curved and sculptured horns reaching 64 inches in length. It is a great prize. A traveller who has recently returned from Angola reports that it is destined to disappear from its limited range unless drastic measures are taken. Even the rare and beautiful okapi, though it lives in the dense forests and travels—a moving patch of brown velvet—only at night, is already threatened with destruction *only twenty-five years after its discovery by the white man*. It is being hounded by the natives into its most distant retreats. Again, who is to blame if it is not the European, who offers rewards to the negroes, and furnishes them with up-to-date arms? Professor Henry Fairfield Osborn, President of the American Museum of Natural History, has said, "We paleontologists alone realize that in Africa the remnants of all the royal families of the Age of Mammals are making their last stand, that their backs are up against the pitiless wall of what we call civilization. Human rights are triumphing over animal rights, and it would be hard to determine which rights are really superior or most worthy to survive."

When our coal and oil are exhausted, the scientific experts can doubtless give us some substitute. But no scientist, says another Nature lover, "can give us back anew those high developed organisms of the plant and animal world which man today is recklessly sweeping out of the list of living things: They can not restore to us the green woods and

their animal life. We preserve with punctilious precision every vestige of the art of the past. The older the documents of earlier historic times, the more eagerly they are coveted, the more highly they are valued. Our collectors gladly pay the largest sums for an old papyrus, an old picture, an object of decorative art, or a marble statue. . . . . But the same man who, in this respect, acts so reverently, so conservatively, looks on with folded arms while treasures are destroyed that ought to be guarded with special affection and care, in these times when the great value of all natural science is so fully recognized." Let archeology wait. The relics of the men of a former time will be in the ground a hundred years from now. But the rescue of the African animals *can not* be delayed. They are falling to the ground as I write.

But mankind, not the animals, is the great sufferer. Sad as is their physical death, it is even sadder to see the shrinking of our own intellectual and spiritual resources as Nature is unhorsed. For just as we need the forests in order that we may keep our water supply, so we crave the living things of the wilderness for our spiritual enlargement. Man is stripping a vast playground of the beautiful creatures that give it life. What will our children and grandchildren enjoy most, the stuffed specimens in museums, or the living creatures in their own home—glorious Africa,—whose vast healthy regions have already become the playground of visiting white women and children? Africa calls us to that simple mode of existence for which Nature originally intended us, and from which our modern life in cities is an abrupt and violent change. For many thousands of years, our ancestors were hunters, herdsmen, shepherds, tillers of the soil, fishermen, sailors; however adapted our intellects have become to the age of machinery, our instincts still point to the outdoor life of the wilds as one great source of our deepest enjoyment. Like love and worship, so hunting, fishing and exploration are portions of our nature of deepest and remotest origin. They are as much a part of a man as his hands. We need a place in the world where we can recapture "The lost arts of wildcraft" in such surroundings, because "the self dependent life of the wilderness nomad brings bodily habits and mental processes back to normal, by exercise of muscles and lobes that otherwise might atrophy from want of use." That there is a dash of the gypsy in everyone is simply a sign of our wholesomeness, and of a past which our natures can not wholly forget. Yet in spite of this, man the conqueror is converting the world as rapidly as possible into a desert of houses and factories. He has vanquished the whole globe, and he is to be master of a dry crust of earth! If only civilized

man had the wit to know what he is throwing away! If only those *in every country* who see the danger could shout a warning to the whole world! If only we could start a campaign to save these creatures, a campaign which is *militant, unified, international!*

There are two rather brighter spots in this picture; first the British animal reservations in East Africa, the Sudan, British Somaliland, British Central Africa, and the Union of South Africa, and, secondly, the Belgian Parc Nationale Albert, established to protect the vanishing mountain gorillas of the Kivu district, in March, 1925. But unprejudiced naturalists assert that even the British reservations are anything but perfect game sanctuaries. In one reserve in the Transvaal shooting was allowed as late as 1907, and the same condition probably prevails today.

There is always the possibility, moreover, of an organized slaughter, with official sanction, such as the massacre of the Addo Bush elephants in 1919. The strongest sentiment for game preservation is in England, but the local government of the colonies is swayed more by the European colonists in Africa than by the British Parliament, hundreds of miles away. Therefore, since the colonials are as much hunters as they are conservationists, the British policy of animal conservation is apt to be modified, from time to time, in individual cases. Someone is always looking for an excuse to break into the reservations.

The most thoroughly satisfactory reservation is the new Belgian Gorilla Park, for which we have to thank the tireless efforts of Mr. Carl Akeley, and the enthusiastic coöperation of distinguished Belgian officials. But mark! This reserve is the result of pure accident. If Mr. Akeley had not been travelling in Central Africa at the precise moment of the century when a certain royal hunter was decimating the gorillas of the Kivu, these great apes—the product of the ages, the cynosure of the eyes of biologists and physicians—would have been extinct today! Why, in future, leave the preservation of such creatures, some possibly yet to be discovered, to blind chance? Will fortune so favor a careless world a second time? For every Nature-lover in Africa, there are a hundred white men whose chief joy is in dealing out death or in adding to a trophy collection. What chance, then, have the wild creatures of any district, of meeting, not their murderers, but their friends, in the areas where shooting is freely allowed?

Indeed, with few exceptions, past efforts at conservation have been by no means wholly successful. We may sum up the defects as follows: (1) Reservations in the British Colonies, and in the Union of South

Africa, are not closed to *all* persons. In one important British reserve, moreover, the Southern Game Reserve of Kenya Colony, every time there is a drought, the natives and their cattle, which are privileged, are apt to take possession of the watering places, thus driving the game from the reserve to the outside districts, where they are foredoomed. (2) An international convention of Powers interested in Africa met in 1900, and devised a set of regulations for animal preservation. But obedience to these rules has never existed, chiefly, it would seem, because the machinery of enforcement, including a *permanent* body to keep watch on conditions, has never been set up. The need of such a permanent organization can not be too strongly emphasized. (3) No such body, to watch conditions and stress rules, could succeed unless the regulations could be enforced equally in *all* the African provinces at the same time. The rules adopted by the 1900 convention, little more than a fine gesture expressing a pious wish, are good rules, but they must be made binding all over Africa. Of what use would it be to insist on the shooting of males only, on closed seasons, on game sanctuaries, on restricted export of skins, horns, and the like, and on the prohibition of grass fires and certain forms of traps, in British Somaliland, if these principles were not, for example, respected in Italian Somaliland just across the frontier? (4) Protection of animals in a given locality must not be the result of accident. Animal extermination must be *prevented*. It can not be cured.

The needed reforms, therefore, seem to call for:

(1) More perfect sanctuary in British and other reservations already established, so that the animals may be protected independent of the vagaries of influence.

(2) The exclusion of natives and native cattle from certain drinking places in certain preserves.

(3) A *permanent* international body to make inter-colonial regulations and keep constant watch on conditions. Game protection in a given spot must not be, as heretofore, the result of a happy accident. Prevention is better than a belated cure.

(4) Enforcement of the established regulations in *all* parts of Africa where they apply.

It will be quite obvious to every reflecting person that what is needed is an organization which is *permanent*, *disinterested* and *international* and has power to enforce its rules. A temporary organization[3] has failed,

[3] The International Game Protection Convention of 1900. Its recommendations were never ratified by the various home governments, much less enforced.

already, to protect African game in general, and the Kivu gorillas in particular. No *single* nation has been always sufficiently disinterested to put the needs of the animals, and of society in general, above the demands of the colonial European hunters. No *single* nation has made genuine animal sanctuaries. There has been a tendency to distinguish between the influential hunter and the weak. No *single* nation can or will patrol all of Africa, or make or enforce uniform regulations on the entire continent. Without intercolonial uniformity of regulation, and of enforcement, there might as well be none at all. In the United States we realize how futile it is to protect our migratory birds, when they are slaughtered just over the border in Mexico. The problem is the same with the migratory game of Africa.

Turning now to the opinions of naturalists who have actually studied conditions in Africa, we find our conclusions strikingly confirmed. Says one "Through the trifling fact that we have ivory balls for billiards, the African elephant goes to destruction. *The individual can not stop this.*"[4] Says another,[5] measures of protection can not succeed "by merely putting limitations on the enjoyment of the chase by the individual hunter. On the contrary, a beneficial result can be obtained *only by all European travellers in those countries interchanging their experiences, collecting material, and exerting themselves to the utmost and in concert* to devise measures that will, as far as may be, put a stop to the threatened extermination." And again, "But how can these measures be enforced, no matter how well they may be thought out?" Finally, Mr. Herbert Lang, of our own American Museum of Natural History, wrote in 1924, "Were there a united great nation in Africa, *with all people acting in concert*, perhaps the problems [of animal conservation] would not be so difficult."

Two of the naturalists quoted wrote before the world war had brought about a new era,—the era of international coöperation. Few persons, whether naturalists or not, seem to realize that there exists in the world today a permanent international organization of surpassing value for the purpose which we are discussing. It is the greatest clearing-house of ideas and information, the greatest organizer of enlightened public opinion, that the world has ever known. It is a telephone exchange for nearly the whole world! It softens the tension between nations by the force of organized public opinion alone. Its

[4] Wilhelme Bolsche, quoted in C. G. Schilling's "In Wildest Africa," 1907 (Italics mine).

[5] C. G. Schilling's "In Wildest Africa" (italics mine).

work among nations at peace is far more voluminous, though less well known, than its deeds among nations on the war-path. Though its main object is to prevent war, it is developing the most astounding number of peace-time activities. Always and always public opinion is its chief force. By this means *alone*, it stopped the Greco-Bulgarian War of October, 1925.

Today, it is dealing with questions as divergent as the standardization of biological sera and the problem of legal assistance to the poor; a study of the question of double income tax, and an investigation of sleeping sickness and tuberculosis in Africa; it has commissions doing nothing but study malaria, tuberculosis, and cancer. It has summoned an international conference which has greatly reduced the passport difficulties of post-war travellers in Europe. It has begun a reform in the calendar, involving a conference, for the first time in history, between delegates of the Vatican, the Church of England, and the Oecumenical Patriarch. Its Health Committee, sitting in Geneva, is the "general staff of a great army at war with disease." It has won successful battles against disease in the field. In 1926 it will cause an extended tour to be made in Africa to study health work and tropical disease. Disease conditions are cabled weekly to Geneva from the far-flung parts of the world. Besides this Health Committee, a veritable mine of world information for doctors, there are the Financial, Economic, and Disarmament committees, the Committee on Intellectual Coöperation, another active committee on world statistics, and another on traffic in opium and other drugs. Then there are the Jurists' Committees and the Permanent Mandates Commission, which is gradually improving the condition of the natives of Africa and elsewhere. Truly it takes no great stretch of the imagination to believe that this League of Nations may in fifty years guide the world in most of its important activities. And if it has already accomplished so much, could it not undertake to employ a dozen observers in Africa to see that the harmless and beautiful game shall receive a square deal, and a permanent commission to guarantee to our children their rightful heritage?

It is not enough to say that nothing in the League of Nations Constitution—the Covenant—*prevents* wild life conservation. Such work is *directly in line* with the whole policy of the League. Article 24 of the Covenant reads in part, "all commissions for the regulation of matters of international interest hereafter constituted shall be placed under the direction of the League," and several such independent commissions have already so applied, and have been admitted. That the League

commissions already established—the Health and the Mandates Commissions—have habitually received reports from the field in Africa is well known. That points to one definite line of action by the ten countries, all League members, which are interested in African Territory. Another possibility is a game protection bureau of the Committee on Intellectual Coöperation, one of the functions of which, according to Gilbert Murray, is "international action for the practical advance of knowledge." (The most practical way to advance our knowledge of African animals is to keep them alive.) This bureau might be called the "Permanent Sub-Committee on the Protection of African Fauna," and its duty might be to collect and publish information on the status and needs of African wild life, so as to promote better coöperation among the friends of wild Nature throughout the world. A third line of action might be through the International Institute of Intellectual Coöperation, of which the League committee of similar name is the governing board. This Institute opened its doors in Paris, November 1, 1925, and is now a going concern. It is staffed by noted scholars of many nations, and it is expected to be a vital factor in the world interchange of scientific and other data. Its financial support is assured, since the French government has pledged two million francs a year to be set aside for its use. Finally, an American committee has already been organized to cooperate with the scholars of twenty-five other nations in furthering international intellectual coöperation. Dr. Robert A. Millikan, the distinguished American physicist, is chairman.

In any case, a set of intercolonial principles or regulations should be drawn up by representatives of the ten countries interested, and whatever body is organized under the League, it should (1) send observers to Africa and receive game reports; (2) make recommendations to the Council or Assembly; (3) publish the recommendations. These would include special investigations in special localities, the making of further reservations on waste land, intercolonial hunting and trapping regulations, and the like. Savages, left to themselves, do not destroy the balance of Nature between man and beast. Europeans with modern firearms have long ago destroyed this balance. Reasoning man must now entrust the League with the task of replacing the lost balance of Nature by a balance of justice and common sense. Nature lovers have rights as well as hunters.

Certain matters already are crying out for adjustment. An American naturalist, tells us, speaking in 1924 of African elephants, that "governments have reaped the benefits of increased income derived from taxes

on permits, and the exploitation of ivory, and have thus consented to their doom. And this has gone on in spite of all assurances to the contrary. . . . . Today, in the Belgian Congo, the natives are killing elephants in the search for ivory, which now brings unprecedented gain." We have already noticed the fact that the ivory billiard ball is the chief factor in exterminating the African elephant in certain sections. The first step, therefore, will be to abolish the traffic in ivory altogether, throughout the whole of Africa.[6] A substitute for ivory billiard balls *must* be found. Similarly the traffic in the horns and hides of the "white" rhinoceri of the Upper Nile must be ended. There is not a moment to lose.

A most important matter which the League body should see to at once is the control of the use by natives of modern firearms, and also, perhaps, of automobiles. These are the two chief enemies of wild life. The natives should have only their primitive weapons. Modern firearms have been the curse of wild life everywhere. The Mandates Commission of the League of Nations is already actively interested in this matter, and would undoubtedly be glad to coöperate.

Organized commercial tours of Africa are another problem. Tourists can do much harm to a wilderness, by lighting fires and indiscriminate shooting, unless closely watched. Cook's tourists have been in Africa, I believe, for some time, and a passenger steamer of a well-known line left New York, January 19, 1926, for the southern and eastern coasts of Africa. The tourists were to visit, among other places, the British East Africa Protectorate, and even the Victoria Falls in the interior! Hunting was on the program. There were 350 passengers, including women and children. There will now be, I suppose, a trail of peanuts and chewing gum from the ocean to Victoria Falls.

The existing game preserves must be set aside as permanent sanc-

[6] According to a British authority on game protection, resident in Kenya Colony, Captain Keith Caldwell, elephant tusks, illegally possessed in Kenya, are now smuggled into Italian Somaliland, and there sold openly. Tusks worth $250,000.00 are thus bootlegged across the international boundary every year, there being no law in Italian Somaliland restricting such sales of ivory. The only real cure for this evil, says Captain Caldwell, is to obtain the coöperation of Señor Mussolini. Our leading American conservationist has just admitted to me that he has failed to interest the Italian government in this problem. Unfortunately he does not command the publicity, great as are his resources, that is behind the League of Nations. On the other hand, the Mandates Commission of the League is now dealing with the possible smuggling of firearms in Africa, under conditions similar to those of the ivory traffic.

tuaries, free from *all tampering and the whims of politics*. "The interest and beauty of such preserves would in future attract admiring visitors in as great numbers as hunters have been attracted in the past," and the preserves, as gigantic zoos, might yield the colonial governments a considerable revenue.

The protection of such rare and beautiful animals as the sable antelope in (Portuguese) Angola, and the okapi in the Belgian Congo, should receive special attention. Native chiefs should be rewarded for protecting them, and the traffic in the skins and horns, both readily recognizable in these cases, should be prohibited.

New animal preserves ought to be created wherever possible. Large areas might be converted into international hunting, camping, and exploring places, thus preserving for all nations a most manly and healthful recreation. A wise policy will reconcile human and animal rights. As Mr. Akeley says, "it will be a long time before one-quarter of the area of this vast continent is required for cultivation. Therefore, the game, if wisely handled, might well be left on the other three-quarters." And there are parts of Africa, like Kenya, where much of the land is unfit from cultivation and practically valueless from being "mountainous or waterless, or forest covered." Again, "European immigration has not filled, and can not fill, the spaces in Africa left empty by the slave wars."[7]

Finally, the League commission will supervise through the colonial government the granting of hunting and camping licenses, the enforcement of regulations, and the exclusion from African hunting territory of all "game hogs" and others who refuse to obey rules, or to respect the rights of others.

Do not misunderstand me. I do not propose anything remotely resembling a superstate. I propose that intercolonial game protection recommendations be drawn by a permanent League game commission, and enforced by the local national governments; that periodical reports by colonial officials be made to this supervising commission; that the commission shall send observers to Africa to check up on these reports, and shall make recommendations to the League Council, which may in turn pass them on to the government concerned. The chief force behind the Council's recommendations is public opinion, and the League's permanent publicity bureau. That governments are becoming increasingly sensitive to public opinion, no one will deny who remembers how slavery was abolished in the

[7] From "Kenya," by Norman Leys, 1924.

Belgian Congo as a result of British opinion. The principle of national colonial government with League supervision is not new. It is the principle behind the Mandates Commission of the League, which I am ready to prove to anyone has so far been a success.

Friends of wild life must act quickly, if we modern men are not to find ourselves masters of a world shorn of much of its beauty at the very stage when, through the development of machinery, we are obtaining increasing leisure to cultivate an interest in the things of the spirit. Two ways lie open to us. One is the path of coöperation among the nations, with, as a consequence, increased happiness and instruction for our children. There is also the path of laziness and inaction. At the end of this short and easy trail lies a desert, and a stillness which is everlasting.

Philadelphia, Pennsylvania.

BATS, BAT TOWERS AND MOSQUITOES[1]

By Tracy I. Storer

[Plate 11]

From time to time during the past decade there have appeared references to the supposed service of bats as aids in the control of malarial mosquitoes. Most of these articles have been in popular magazines (see the "Readers' Guide to Periodical Literature" for exact references) but there has been at least one critical paper on the subject (Howard, 1920) which, however, appeared in a periodical not often seen by mammalogists. Most of the publicity given the subject has been in praise or criticism of the activities of Dr. Charles A. R. Campbell, a physician of San Antonio, Texas, who for fifteen years or more has been active in the establishment of artificial roosts for bats, premised on the belief that the bats were effective agents in the control of malarial mosquitoes. Dr. Campbell (1925) has recently published a book describing his work with bats; this volume is reviewed elsewhere in this Journal (see p. 136).

While in Army service in 1919 the writer was stationed in San Antonio where he made the acquaintance of Doctor Campbell. Upon request the latter kindly afforded an opportunity to visit the first of the suc-

[1] Contribution from the Zoological Laboratory, College of Agriculture, University of California.

cessful bat roosts situated near Mitchell Lake, ten miles southwest of San Antonio. This visit took place on January 10, 1919.

The roost mentioned was the second to be constructed, the first having been erected at the field laboratory of the U. S. Bureau of Entomology, six miles south of San Antonio, in 1909. The Mitchell Lake roost was completed on April 2, 1911. In 1919 Doctor Campbell informed the writer that additional single roosts had been constructed at the following places: In the Mexican quarter of San Antonio, about two miles southwest of the center of the city; at the Southwest (Texas) Insane Asylum near San Antonio; and at the country place of Mr. Albert Steeves about fifty miles northwest of San Antonio. Four roosts were constructed at Orange, Texas. More recent magazine articles report the construction of other roosts near San Antonio and elsewhere in Texas.

The "bat roost" as conceived by Doctor Campbell has been patented in the United States (Patent No. 1,083,318, issued January 6, 1914. Patent Office Gazette, vol. 198, 1914, pp. 20–21). The individual towers as built under Doctor Campbell's direction differ somewhat in details but the Mitchell Lake tower may be described as fairly typical. The tower is truncately pyramidal in shape, supported on stout posts. The base measures about twelve feet square, the top approximately six feet square, and the tower is about twenty feet in height. The outside is covered with drop siding (protected beneath by tar paper according to Bishopp in Howard, 1920, p. 1793). Further details from the writer's notebook are as follows.

Internally, the tower is comprised of three distinct parts, a winter or "hibernating" roost against the walls of the structure, within this a summer roost, and a central open shaft the entire height of the tower the bottom of which forms a pit for the accumulation of the guano.

Winter Roost: To the two by four inch studs supporting the outer walls of the tower are nailed strips of wood one by one inch, spaced one inch apart and all inclined at an angle of forty-five degrees. Across these ordinary laths are nailed horizontally with one-eighth inch spaces between adjacent laths and end-to-end breaks in every third lath to permit the bats to crawl from one to another of the narrow compartments so formed. On top of the laths another course of one by one inch strips is nailed and this is repeated until there are eight to ten alternate courses of diagonal strips and horizontal laths.

Summer Roost: This is merely a resting place for the bats during the day; it consists of a series (some 1400 in all) of short boards with numer-

ous transverse grooves to afford the bats foothold when resting. These short boards are suspended vertically on the under sides of a series of slanting shelves of matched boards. The bottoms of the grooved boards are held in place by poultry netting. The slanting shelves serve to shunt droppings into the central open shaft of the tower whence they fall into the guano pit.

Guano Pit: This is at the bottom of the pyramidal tower. It is the full size of the base of the tower and about two and one-half feet in depth. On the under side of the compartment there is a chute which allows the guano to be run directly into sacks or into a wagon driven underneath the tower. Entrance to the tower is effected at the eaves, under the pyramidal roof, and through a large louver-door about two feet in width extending the full height of the tower. The accompanying illustrations will serve to make clear the details of construction of the tower.

Doctor Campbell contends that the bats feed upon mosquitoes, more particularly upon malarial mosquitoes, and that thereby they are effective agents in the control of malaria. He claims that malaria has been reduced in the territory surrounding the Mitchell Lake roost. It is upon the basis of this claim that several of the towers enumerated above have been constructed. The designation "Hygieostatic Bat Roost" has been applied to one or more of the towers in this connection.

Upon his visit to the Mitchell Lake tower on January 10, 1919, the writer gathered a small amount of the guano then in the pit for purposes of subsequent examination. Skeletons of bats which had died in the tower and fallen into the guano pit showed the species tenanting the tower to be *Tadarida mexicana*, the common "house" bat of the American southwest.

Shortly after returning to Berkeley a sample of this guano was submitted to Professor William B. Herms of the University of California who for a number of years has been engaged in malarial control studies in California and is consequently throughly familiar with the details of structure of malarial mosquitoes. Pellets of guano dissolved in hydrogen peroxide were carefully examined under the microscope without showing any scales, bristles or other structural elements which could be identified as belonging to malarial mosquitoes.

Sometime later a request to Doctor Campbell for additional material brought a second specimen of guano. This was examined by the writer without showing any fragments which might be considered as having belonged to mosquitoes.

Wishing to have expert examination of the two lots, a representative sample was taken from each and forwarded to the United States Bureau of Biological Survey with request for a careful examination by the Bureau's experts. In returning a report upon the samples Dr. E. W. Nelson says with respect to the procedure of examination used:

> This material has been examined independently by three members of the Division of Food Habits Research, one of whom is a specialist in Diptera. After the material was examined by ordinary methods involving prolonged study under high magnifications, the additional precaution was taken of boiling the samples, a method which expands and floats out any wings of insects that may be present. Nevertheless no mosquito remains whatever were found and indeed only a trace of a single insect of the whole order of Diptera.

The detailed report on the samples is as follows:

Sample 1. Bat guano from roost established by Dr. C. A. R. Campbell, at Mitchell Lake, San Antonio, Texas, collected by Doctor Campbell. The material was chiefly remains of moths but included also traces of the following insects: ground beetles (Carabidae), 2; leaf-chafer (*Serica* sp. ?), 1; weevil, 1; leaf-beetle (Chrysomelidae), 1; and an unidentified beetle; ant (*Dolichoderus* sp.), 1; water boatmen (Corixidae), several; stink-bug (Pentatomidae), 1; green blow-fly (Muscidae), 1; and small dragonfly, 1.

Sample 2. Bat guano from same source, collected by Tracy I. Storer of the University of California. The bulk of the material was remains of moths; but the following insects also were detected: leaf-hopper (Jassidae), 1; water boatmen (Corixidae), 1; *Corizus* sp., 1; bug (Heteroptera), 1; leaf-beetles (Chrysomelidae), 2; weevil, 1; ground beetle (Carabidae), 1; unidentified beetle, 1; and ant, 1.

The percentage of moth remains in both cases was well over 90. The examinations were by W. L. McAtee, E. R. Kalmbach, and J. R. Malloch.

It occurred to the writer that possibly mosquitoes if present might, by reason of delicate structure, be reduced beyond recognition in passage through the alimentary tract of a bat. A query on these lines to the Biological Survey elicited the following response:

> There is no doubt that if any mosquitoes had been eaten by these bats that remains of them would have been found in the guano. The mouth parts of the mosquitoes are not only well chitinized but very characteristic and could not have been overlooked. The wings also, like those of all insects, resist digestion to a marked degree and when expanded by the process used in the analysis would have been easily recognizable.

The writer has examined guano from roosts tenanted by *Tadarida mexicana* in California without seeing any scales which *he* would suspect of being those of mosquitoes.

The conclusion seems inevitable therefore that the bats in the San Antonio roosts were not feeding upon mosquitoes at the time when the above-mentioned samples were taken. Nor is there any evidence to show that this species of bat elsewhere feeds upon mosquitoes.

This conclusion is not wholly unexpected. The forage range of *Tadarida mexicana* is generally up away from vegetation. The malarial mosquitoes ordinarily keep rather close to the ground; an old southern belief that a person is less liable to contract malaria when sleeping on the second floor of a house finds a basis of fact in the observed habit of *Anopheles* of keeping close to the ground and often under cover of vegetation.

The conclusion seems justified that *Tadarida mexicana* does not ordinarily feed upon mosquitoes and that its value is negligible in the control of malaria. *Tadarida* and malaria-bearing *Anopheles* have for years existed simultaneously in many of the towns of the Sacramento Valley in California without any appreciable change in the malarial index of the human population until the introduction of appropriate sanitary control measures.

In a letter written in 1923, Dr. L. O. Howard told the writer of having accompanied the late Professor Battista Grassi on an expedition to Fumacino, Italy, on June 4 of the same year. He says: "At dusk we saw numerous bats emerging, and Grassi told me that, in his opinion, bats in Italy have no effect on the malarial incidence, and that bats are very numerous in the most malarial parts of Italy."

The evidence thus far adduced is against the notion that colonial bats are effective in mosquito control. But other, more favorable, conclusions may be drawn with respect to the services of the bats. I refer to their feeding upon moths and the accumulation of guano which is usable as fertilizer. Some at least of the moths captured by bats feed in their larval stages upon economic plants; and, while the bats can scarcely be expected to control these insects down to the stage where the damage they do is negligible, I think we may safely infer that the bats are one agency among several in keeping down the numbers of insects. Secondly, with respect to guano, under conditions existing just after the war it would have been profitable to have constructed bat roosts (provided they could be colonized by bats) merely for the annual crop of guano which could be collected from the roosts. The scattered figures

on this subject in Doctor Campbell's book indicate that, even with building costs as there indicated, a tower situated in a region affording plenty of bat food would in the long run prove a profitable investment.

Bat guano is regularly gathered from caves in various parts of the American southwest (Texas, Missouri, Arizona) and in Porto Rico in commercial quantities (Albrecht, 1921). This guano, while variable in content of nitrogen and phosphorus according to the atmospheric conditions under which it is accumulated and to the length of time since deposition, is, nevertheless, a valuable fertilizer.

In the Mitchell Lake roost Mr. Bishopp (quoted in Howard, 1920) reported that in 1913–14 the amount of guano accumulated was almost negligible. On January 10, 1919, the writer saw a mass of guano 1½ to 2½ feet in depth. Doctor Campbell stated that this was the 1918 "crop." He then reported that the 1917 "crop" weighed 2900 pounds and was sold for one hundred dollars. In his 1925 book the 1917 crop is given as 2996 pounds (plate opp. p. 132), the 1918 crop, collected January 12, 1919, as 4012 pounds, and the 1921 crop as 4558 pounds (plate opp. p. 170). It would be expected that at first a relatively small number of bats would enter such a roost and that the annual increments in population would remain in the tower and augment the population. That such is the case with the tower in question is suggested by the increasing amounts of guano harvested.

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Zoological Laboratory, University Farm, Davis, California.

Fig. 1

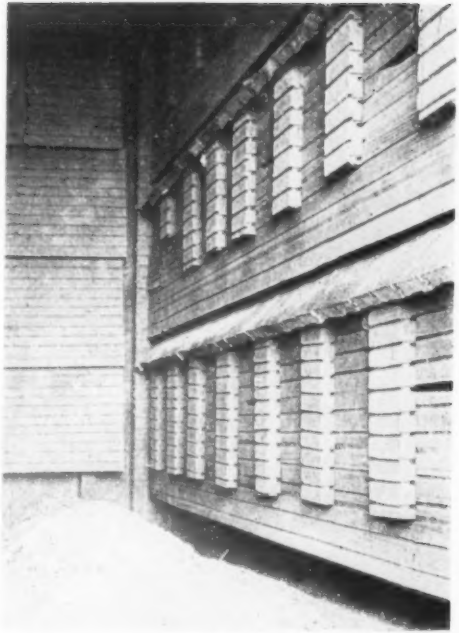

Fig. 2

Bat Roost Erected at Mitchell's Lake, near San Antonio, Texas, in 1911, by Dr. C. A. R. Campbell. Photographed January 10, 1919

The view at the right shows interior of the roost. Note guano in pit at bottom, "summer" roosting boards on sides, and dark crevices above slanting boards which connect with other parts of summer roost.

UNIV. OF MICH.

AGE OF THE ANIMAL AND SLOPE OF THE GROUND SURFACE, FACTORS MODIFYING THE STRUCTURE OF HIBERNATION DENS OF GROUND SQUIRRELS

By William T. Shaw

[*Plate 12*]

Investigations on the life of the Columbian ground squirrel (*Citellus columbianus columbianus*) at Pullman, Washington, covering five years from 1910 to 1915, during which period 136 dens were excavated completely, called attention to variations in den structure depending first upon the age and size of the animal and second upon the surface of the land in which the den was located. These two factors will be considered in this paper.

AGE OF THE ANIMAL

Owing to the great difficulty experienced in finding squirrels in hibernation, we became familiar with the dens long before we found the animals themselves. A difference in the size of the hibernation cells was noticed and also a wide variation in the depths at which they were located in the soil. Occasionally we were informed by farmers that they now and then broke into nests of squirrels hibernating at plough depth, while line men setting posts and railroad grade men making cuts were finding squirrels deeper down in the soil.

Careful measurements of 54 hibernation dens showed that the size and depth of the cells bore a distinct relation to the weight and age of the squirrels occupying them.

Hibernation dens of old squirrels. The term "old squirrel" as here used means an individual that has been through at least one hibernation. It was found that the older and larger the squirrel, the better and more complete was the structure of its hibernation cell and the deeper it was in the soil. The hibernation den is often elaborately and perfectly built and in flat regions finished with a well-established drain. It was further found that the cells lie from 18 to 42 inches below the surface and that their average diameter was about 8.5 inches.

A typical though elaborately prepared den of an old squirrel was found in a wide and almost level field. The cell was large, 10 inches in all diameters, and placed 40 inches below the surface (fig. 1). It was occupied by a large adult male squirrel, which weighed 532 grams at the time it emerged from hibernation.

Hibernation dens of young squirrels. By the term "young squirrel," is here meant a squirrel going into hibernation for the first time. It is significant that young or immature squirrels are capable of hibernating

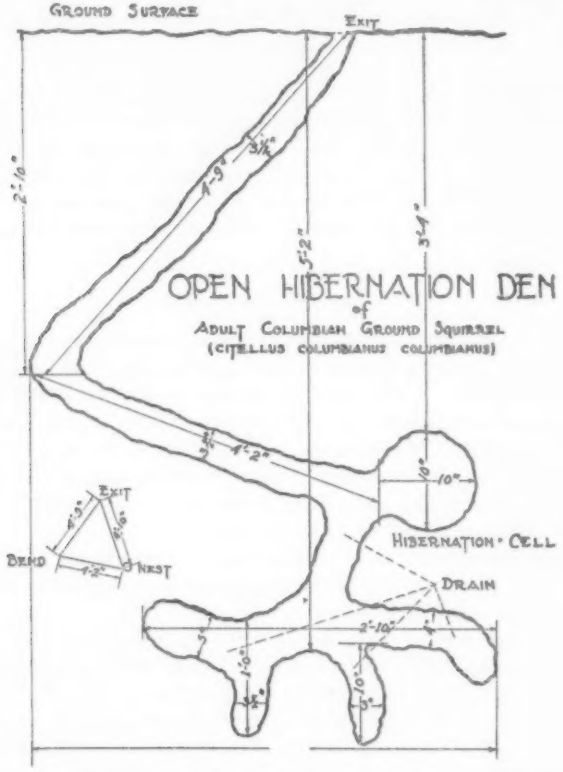

FIG. 1. HIBERNATION DEN OF ADULT COLUMBIAN GROUND SQUIRREL

Note large hibernation cell placed deep in the soil. The den was in a flat field and provided with a well constructed drain.

in much shallower soil than old squirrels. As a rule, the dens and nests of these young squirrels are very poorly constructed, probably because the young squirrel, during its three months of activity, is too much engaged in maturing and preparing for hibernation, and does not have

sufficient time to construct an elaborate den in which to pass the adverse periods of its first summer and the following winter. Each of these dens is simple, and consists of a cell of small diameter, about 6.6 inches all round, located but a few inches deep, sometimes not more than 6 inches below the surface. The cell is practically like that of the hibernation cell made by the older squirrel, and is reached by a short neck leading into what appears to be an old descending burrow of the summer den which drops at an angle of 45 degrees. Such a den is sometimes found

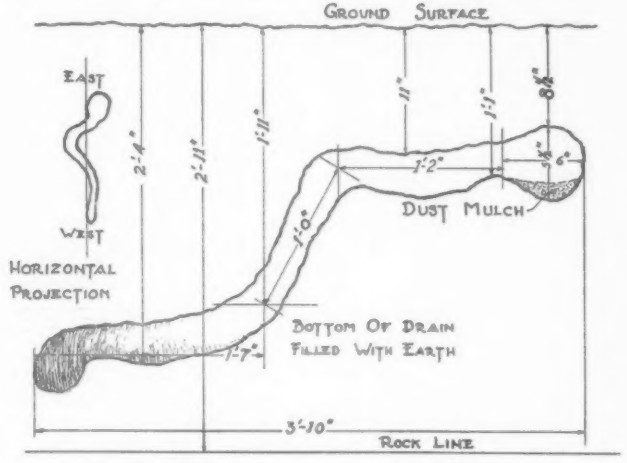

FIG 2. SEALED HIBERNATION DEN OF YOUNG SQUIRREL WEIGHING 355½ GRAMS

This den was placed only 2 feet 11 inches above rock, a situation not suitable for a larger squirrel, because it could not place the hibernation cell deep enough and still find room for a drain. The nest cell averaged a little less than 6 inches in diameter, and was placed only 8½ inches below the surface.

in rather shallow soil, the bottom of the drain reaching bed-rock. In a den of a young squirrel the neck, entrance, and drain are frequently all in one (fig. 2).

A den of this type was found on January 17, 1914, 8½ inches below the surface. The cell averaged a little less than 6 inches in all diameters and was occupied by a young male squirrel weighing 355½ grams. Instances of still shallower hibernation by young squirrels are shown in table 1, which expresses the relation between the age and weight of squirrels and the depth at which they hibernate.

The habit of shallow hibernation as found among young squirrels in the wild state was also confirmed with young squirrels in semi-captivity. The nests of two such young were examined and found to be only a few inches below the surface.

TABLE 1

DATE	SEX	WEIGHT	VERTICAL DIAMETER	FRONT TO REAR DIAMETER	LATERAL DIAMETER	DEPTH FROM SURFACE OF GROUND TO TOP OF CELL
		grams	*inches*	*inches*	*inches*	
March 7, 1914.....	Male	609	10.0	10.0	10.0	3 ft. 8 in.
December 13, 1913.....	Male	594	9.0	9.5	9.0	2 ft. 6 in.
February 21, 1914.....	Male	579	10.5	10.0	10.0	3 ft. 3 in.
March 3, 1915.....	Male	557	10.0	11.0	10.0	3 ft. 3 in.
March 7, 1914.....	Male	536	10.0	10.0	10.0	3 ft. 1 in.
March 5, 1915.....	Male	532	10.0	10.0	10.0	3 ft. 4 in.
March 1, 1915.....	Male	522	9.0	11.0	9.0	3 ft. 4 in.
March 6, 1914.....	Male	517	9.5	9.5	9.5	3 ft. 2 in.
November 15, 1913.....	Male	510	6.5	7.0	6.5	2 ft. 5 in.
March 6, 1915.....	Male	467	9.25	9.25	8.25	3 ft.
February 25, 1915	Male	465	8.25	8.25	8.0	3 ft. 5 in.
March 3, 1915.....	Male	449	9.0	9.25	7.25	3 ft. 4 in.
March 1, 1915.....	Male	435	9.25	11.0	9.0	2 ft. 8 in.
February 21, 1914.....	Male	407	8.0	9.0	9.0	1 ft. 10 in.
November 22, 1913.....	Female	390	6.0	5.25	6.0	3 ft.
December 30, 1913.....	Female	371	6.5	7.0	6.5	1 ft. 8.5 in.
March 7, 1914.....	Female	369	7.5	8.5	7.5	1 ft. 7 in.
March 12, 1914.....	Male	366	6.5	6.5	6.0	7 in.
January 17, 1914.....	Male	355½	5.5	6.0	5.5	8.5 in.
March 12, 1914.....	Female	340	7.5	7.5	7.5	2 ft. 5 in.
January 17, 1914.....	Female	312	6.0	6.5	6.0	6 in.
December 30, 1913.....	Female	275	5.5	5.25	5.5	1 ft. 2 in.

SLOPE OF THE GROUND SURFACE

In the second part of the investigation, that in relation to the modification of the den depending upon the topography of the territory under consideration, the observations here related were obtained by the same field work as for the previous part of this paper.

Dens of the flat land. It was not long before we noticed that the type of hibernation den found under a flat surface was provided with what was unmistakably a drain (fig. 4). Most of the dens in such situations were furnished with them, some with a simple burrow leading down from the nest and always protecting the nest by being placed in front of

the entrance to the cell; others with several drain burrows, as shown in the den of a large old male squirrel (fig. 1). That these structures were very efficient was demonstrated by my attempting to flood the nest through a shaft leading to it. The water followed the burrow to the cell but was diverted into the drain, leaving the nest entirely dry.

Dens of the hillside. Dens on the sides of hills are found at varying distances from the top or botton of the hill, but always on ground having considerable slanting surface.

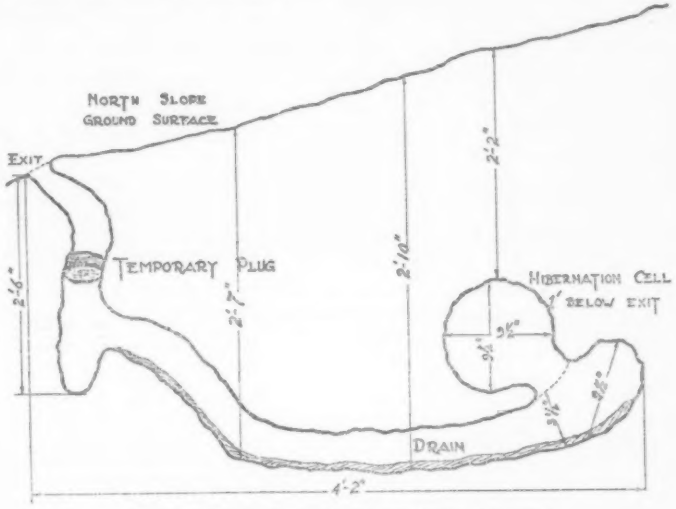

FIG. 3. HIBERNATION DEN ON STEEP HILLSIDE

The hibernation cell is set well back in the hill, and only one foot below the exit. Temporary plugs are found commonly in dens of recently awakened squirrels. One of their purposes would seem to be to keep out the cold.

As we had expected, we found that some of the dens on the tops of hills had no drains other than the ascending burrows which served both as necks and drains. Such a condition is shown clearly in figures 3 and 5. The exit to the den shown in these figures was discovered on February 27, 1914. When excavated it was found to contain an adult squirrel which had but recently awakened from hibernation. Other dens found on this slope were of this type, while only an occasional den was provided with a drain. So frequent was this type of den that there remains no doubt that it is the prevailing type for the hillside situation.

SUMMARY

1. During extended work on the life history of the Columbian ground squirrel it was noticed that the form of the hibernation den was influenced by the age and size of the squirrels and by the topography of the country.

2. The dens of old squirrels or those having passed at least one hibernation were found to be more elaborately constructed and placed at a greater depth than those of young squirrels hibernating for the first time.

3. The dens of young squirrels appeared to be poorly constructed; possibly reconstructions of old summer dens, and the cells were frequently very near the surface.

4. A tabulation of the observations noted in 2 and 3 expresses the points clearly and rather fully.

5. Many hibernation cells were found guarded by drains; well constructed in the case of the old squirrels hibernating in flat country; substituted by ascending burrows in the case of cells of young squirrels; and lacking in dens on steep hillsides. This was the rule, with the exception of an occasional den of an old squirrel found with no drain in a flat country and conversely with an occasional hillside den possessing a drain.

Pullman, Washington.

FIG. 4. HIBERNATION DEN IN FLAT COUNTRY

Even in mid-winter the nest of the ground squirrel is in a fresh dry condition, owing to the preparation made by the animal to keep it so. The squirrel is standing in the drain beneath its den. This picture illustrates the den of a large adult squirrel. November 15, 1913.

FIG. 5. HIBERNATION DEN ON STEEP HILLSIDE

Here the squirrels make no provision for drainage of their nests, and rely upon horizontal or ascending burrows leading to the nest. *A*, represents the exit; *B*, the nest; *C*, the lowest point of the drain. February 27, 1914.

NOTES ON THE BREEDING OF WOOD RATS OF THE GENUS NEOTOMA

By Edward R. Warren

In reading Burgess's "Animal Book" to my small daughter I came across the statement that "Mrs. Trader" has "two to five babies at a time and raises several families in a year." This did not particularly attract my attention on the first reading, but having to reread the book to the aforesaid young lady several times, it gradually dawned upon me that this did not seem to be quite in accordance with my own experience and impressions. I had been of the opinion that one litter a year was the rule. Therefore I began to look into the matter.

Dr. E. W. Nelson's "Smaller Mammals of North America" is evidently the authority for the statement in the Burgess book. Nelson says: They are prolific animals and each year have several litters containing two to five young. Practically what Burgess says.

I have gone over my notes relating to those species with which I have come in contact, and have also examined the literature at hand, and this paper gives the results of this study. I take up the species in the order followed in Goldman's monograph of the genus.

Neotoma floridana baileyi. Bailey's Wood Rat. My experience with this species is limited, as I collected it only at Wray, Yuma County, eastern Colorado, with the exception of one male taken at another locality. My work at Wray was done the first week in March, 1907, when several specimens three-quarters adult size were taken. Could these have been born late the previous autumn? My notes have no records of embryos in the adult females taken at Wray.

Neotoma micropus micropus. Baird's Wood Rat. I collected this species at Monon, Baca County, Colorado, close to the Kansas line, in 1905. Three embryos were found in females taken April 28 and May 2. A female two-thirds grown was taken April 28, a three-fourths grown male April 30, and a female of similar size May 2.

Mearns (1907, p. 471) says: "A female taken at Fort Clark, Texas, January 13, 1893, would have produced three young."

Neotoma micropus canescens. Hoary Wood Rat. Mearns (*l. c.*, p. 472) says: "A female taken at Fort Hancock [Texas] on the Rio Grande, contained three large young on June 24."

These records of Mearns and myself would indicate that *micropus* produces at least two litters annually.

Neotoma albigula albigula. White-throated Wood Rat. "White-

throated wood rats are born at all seasons of the year, but perhaps not in winter in the higher portions of their habitat. Two females would have given birth to three young each and four to two each." Date and locality not stated. (Mearns, *l.c.*, p. 479.) Again he remarks: "Three females taken at Monument No. 15 [N. M.], March 31 and April 3, 1892, contained 2, 1 and 3 foetuses respectively." (Mearns, *l. c.*, p. 483.)

Neotoma albigula venusta. Colorado Valley Wood Rat. Grinnell (1914, p. 234) says concerning this species: "We found small young as early as February 24 and 25 at Mellen, and from that date on to May 5, near Yuma. It is probable that the breeding season is just about closed by the time that the annual overflow [of the Colorado River] begins, so that young as well as adults are able to seek safety for the brief period of exile by assuming arboreal habits or swimming to higher ground." Here also there seems to be a possibility of two litters in a season.

"Young were found at Seven Wells [California] April 15, and a female taken at Gardner's Laguna [Lower California] April 20 contained 2 small foetuses." (Mearns, *l. c.*, p. 475.)

Neotoma albigula warreni. Warren's Wood Rat. This subspecies I encountered at Gaume's Ranch, northwestern Baca County, Colorado, and also several miles westward at Irwin's Ranch, in northeastern Las Animas County. At the former locality, three embryos were found May 20, 1905, and three small embryos May 22. At the other place two small embryos were found April 28, 1909. No immature specimens were taken at either place; therefore it may be inferred that the breeding season was just beginning, though that is not necessarily the case.

Neotoma mexicana fallax. Colorado Wood Rat. Though this species is common about my home at Colorado Springs, it so happens that all my specimens were collected in autumn and winter. I have taken immature individuals in November. I have, however, taken this animal in other parts of Colorado, and have notes bearing on the matter in hand. A nursing female was taken at Cortez, Montezuma County, elevation 6,200 feet, April 4, 1906. At Coventry, Montrose County, 6,677 feet, two females each contained two large embryos, April 9, 1908. At Bedrock, Montrose County, April 16, 1908, two foetuses, and April 17, three, these being the largest. At Sieber Ranch, western Mesa County, 5,675 feet, a specimen captured May 12, 1912, contained four large foetuses, and a young one two-thirds grown was taken May 13. At San Acacio, Costilla County, 7,737 feet, the latter part of June, 1912, nearly full-grown juveniles were trapped, though no pregnant females were taken. A considerable series of the animals was trapped here because of the occurrence of melanistic individuals.

Cary (1911, p. 118) says he surprised a female *N. fallax* which "glided away like a shadow in the semidarkness, with two young about quarter grown clinging to her teats." This was July 23, 1906, near Boulder. He also states that a female collected by Loring near Loveland, May 1, contained three small foetuses.

It seems quite evident that in some localities this species has at least two litters a year.

Neotoma desertorum. Desert Wood Rat. Concerning the desert wood rat of the Colorado River Valley, Grinnell says (1914, p. 235): "Fifteen of the specimens taken at the different stations are young of varying sizes. Two very small young of 172 and 167 mm. length, respectively, were trapped March 6 and 7 at The Needles, indicating early breeding. Others nearly as small were taken at Pilot Knob, May 10; so that there is not such constancy in breeding time as in certain other rodents of the region." Might not this also indicate two litters?

I have met with this species at Mack, Mesa County, Colorado, 4,543 feet. April 24, 1912, a female with five large embryos was taken, and two juveniles two-thirds grown April 25. This shows early breeding and a probability of at least two litters during the year.

Neotoma fuscipes streatori. Streator's Wood Rat. Grinnell and Storer (1924, p. 119) say of this species that "The breeding season, ... to judge from the capture of strictly juvenile specimens, includes most of the warm months of the year." They mention a juvenile trapped May 19, possibly born in March, and an immature taken November 24, that could not have been born earlier than September. The observations of these authors would show but one or two young in a litter, but probably two or more litters in a season. This species is found in the lower elevations of the Yosemite region, in Upper Sonoran and Lower Transition Zones.

Neotoma cinerea cinerea. Gray Bushy-tailed Wood Rat. Dixon (1919, p. 62) gives some interesting data on the breeding of the gray bushy-tailed wood rat. The animal's habitat had a vertical range from 5,000 to more than 11,000 feet, from the piñon belt to Alpine-Arctic. The breeding season naturally varies with the altitude, from the middle of May in the piñon belt to the first of September at 11,000. This statement is based on the records of pregnant females collected. The number of embryos varied from one to five, the average being close to four. Dixon states that so far as is known but one litter is raised in a year.

As to the gray bushy-tailed wood rat of the Yosemite region Grinnell and Storer say (1924, p. 122): "The young of the Bushy-tailed wood

rat are produced during the midsummer season. One female, taken in Lyell Cañon on July 17, 1915, contained 3 embryos. . . . . Several females captured between July 9 and 21, 1915, gave evidence of having recently suckled young. By the last week of August young were being trapped in considerable numbers, and were then from one-fourth to one-half the weight of the parents."

Neotoma cinerea saxamans. Northern or Osgood's Bushy-tailed Wood Rat. Swarth (1922, p. 170) says concerning the northern bushy-tailed wood rat: "A young one taken at Telegraph Creek on June 9 was about one-third grown. Others were trapped at Glenora three weeks later of about the same size. Three adults caught at Telegraph Creek on June 9 contained embryos; two had three each, one had four."

Neotoma cinerea orolestes. Colorado Bushy-tailed Wood Rat. Although I have collected many specimens of this rat, and at all seasons, I have, very curiously, no records of pregnant females. I have, however, taken various immature and juvenile examples. At Crested Butte, Gunnison County, 9,000 feet, young three-fourths grown were captured the last of June and early in July. At Lake Moraine, El Paso County, 10,250 feet, immature individuals were taken the last of August, 1905. At Grand Junction, 4,600 feet, immatures were caught the last week of September, 1905. July 21, 1907, on the Grand (Colorado) River, 12 miles above Glenwood Springs, an immature specimen was taken. One which seemed to be immature was taken near Colorado Springs, December 30. June 16, 1911, a half grown young one was caught near Log Cabin, Larimer County, 7,450 feet. July 24, 1911, an immature male was taken at Buffalo Pass Sawmill, Jackson County, 8,880 feet. Apparenty this species breeds in the early summer, and has only one litter.

Neotoma cinerea arizonae. Arizona Wood Rat. At Cortez, Montezuma County, April 4, 1906, a nursing female was taken, also one carrying six embryos, and another with four embryos on the 6th. At Coventry, April 13, 1908, a female with four foetuses was trapped, and on the 19th a nursing female.

These early dates give me the impression that this subspecies may have more than one litter in a season. It inhabits a region where warm weather begins earlier and lasts longer than is the case with the habitats of most of the other subspecies of this group, with the possible exception of the pallid wood rat.

Neotoma cinerea cinnamomea. Cinnamon Wood Rat. Goldman (1910, p. 98) considers this merely a pale form of *orolestes*. However that may be, I prefer to keep it separate for the purposes of this paper.

Two three-fourths grown juveniles were captured at Douglas Spring, Moffatt (formerly Routt) County, June 26, 1907.

Neotoma cinerea rupicola. Pallid Wood Rat. Cary (1911, p. 114) reports two nursing females and two young about one-fourth grown taken near the Chimney Cliffs, Logan County, June 4 to 8, 1901. June 6, 1911, I trapped three nursing females at Pawnee Buttes, Weld County.

The meager data on the last two subspecies gives but little information, except that it shows that the animals breed in late spring and early summer.

SUMMARY

It hardly seems worth while to give a summary of conclusions from the above rather scanty data, and it is briefly:

1. The round-tailed wood rats appear to have two or more litters annually, at least where the climatic conditions are favorable.

2. The bushy-tailed wood rats have but one litter in a season, with the possible exception of the Arizona wood rat. I have no opinion to express concerning the two subspecies mentioned last.

3. The number of young in a litter varies from one to six, litters of the round-tailed forms apparently averaging less in number than those of the busy-tailed rats.

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A NEW HIGH ALTITUDE LIMIT FOR THE AMERICAN BISON

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INTRODUCTION

Whereas the geographic distribution of the American bison in its wild state has been worked out with the great thoroughness, far less attention has been given to the range of altitude through which the animal roamed. All authorities[1] agree that the bison, though primarily a plains animal, inhabited the Rocky Mountains, the Wasatch Mountains, and other high mountains of the west, whither it went to forage during the summer months and whither it was driven for protection during the latter years when the menace of extermination closed in over the plains. But in the literature there is a dearth of data on the question of exactly what altitudes the bison achieved in the high mountains.

J. A. Allen states:

> In the summer of 1871 I found their [buffalo] skulls still frequent in South Park and up the valley of the South Platte to its extreme source. They were very frequent at and above Montgomery, and even on the neighboring mountains above timber-line, showing that not many years ago the buffalo ranged over the grassy slopes of the mountains even to above the limit of the timber. . . . .
>
> Dr. Hayden informs me that a band of eighteen was seen by one of his parties near Pike's Peak in 1873, and that in 1875 there was a band of about nineteen on the west side of Pike's Peak, and another band of about sixty near Mount Lincoln, in the South Park. Mr. C. E. Aiken, probably referring to these, writes me that he knows of but two bands existing at the present time (February, 1876) in the mountains about South Park, one of which "grazes on the mountains at the head of Tarryall Creek, and is frequently found above timber-line; the other ranges in the rugged mountains south of Pike's Peak, and numbers some thirty or forty individuals."[2]

Dr. William T. Hornaday states that bison ranged "the Rocky Mountain parks on the continental divide to an elevation of 11,000 feet."[3] In a letter dated September 17, 1925, Doctor Hornaday informs

[1] For example, see the following authoritative works on the bison:

History of the American Bison, by J. A. Allen. U. S. Geological and Geographical Survey of the Territories" (Hayden) for 1875. Pp. 447–448, 461, 511–520, 533–534, and 540.

The Extermination of the American Bison, by William T. Hornaday. Report of the U. S. National Museum (under direction of The Smithsonian Institution) for 1887. Pp. 407–412.

[2] Op. cit., pp. 533–534.

[3] The American Natural History, by William T. Hornaday. Scribner's, 1914. Pp. 8–9.

the writer that this maximum elevation is based upon the well authenticated report of a buffalo skull found in Two Ocean Pass, Yellowstone National Park.

So far as the writer has been able to determine, these two references are the only ones which afford information of any exactness on the question.

The interest of the writer in the subject dates to the summer of 1924, when he discovered bison remains in the Black Hills of South Dakota. During the past summer of 1925, while engaged in geologic field work, the writer explored the eastern slopes of the Medicine Bow Mountains, located thirty-five miles west of Laramie, Wyoming. These mountains constitute a spur of the Rockies beginning in north-central Colorado and trending northwestward into Wyoming to Elk Mountain, a distance of about fifty miles from the Colorado-Wyoming line. Their range in altitude in Wyoming is from about 7000, the altitude of the Laramie Plains at their base, to 12,005 feet, the altitude of Medicine Bow Peak. As these mountains extend through what was once the heart of the bison country, the writer hoped that in them he might obtain evidence bearing on the former distribution of the wild mountain bison. Such evidence was found in gratifying abundance, and is here set forth for the reason that (*1*) it throws light on the habits of the mountain bison, and (*2*) it may establish a new high altitude limit for the species. The writer hopes that the presentation of these data will stimulate the accumulation of further evidence pertaining to this subject.

FIELD EVIDENCE[4]

(1) In the valley of Nash Fork, five miles northwest of Centennial, the writer found four bison skulls, all at an elevation of approximately 9500 feet. They were scattered along the margins of glacial marshes, a rather surprising occurrence, as there one would expect bones to decompose rapidly on account of the moisture. Three of the skulls may have been moved from their original positions, as there were no other associated remains; the fourth, however, very much decayed, was no doubt in place as it was associated with a number of bones certainly

[4] The altitudes given in this paper were all obtained from the Medicine Bow Quadrangle Map, a topographic map published by the U. S. Geological Survey. They were taken with considerable care, and if in error at all, are likely to be too low rather than too high. Locations, of course, refer to the Medicine Bow Quadrangle Map.

those of bison. Two of the skulls were in a state of good preservation; one of these is now in the possession of the writer.

Interpretation. The finding of these remains suggests that during the summer months bison regularly came as high as these meadows (9500 feet) to graze. Nash Fork and its tributaries to the north flow through a very broad, moraine-filled valley in which there are open woods, glacial marshes, and treeless meadows. These conditions would appear ideal for summer pasturage. There is a tradition among residents in the region that during summer months bison were once abundant in this valley. The discovery of these remains bears out the tradition.

(2) In the woods on the plateau which lies east of the Snowy Range, the writer found a skull in good condition at an altitude of 10,500 feet (Sec. 11, T. 16 N., R. 79 W.).

North of the Snowy Range at an altitude of 10,750 feet (approximately equivalent to timberline) just north of a small glacial lake (unnamed: located in the S.E. corner of Sec. 33, T. 17 N., R. 79 W.) the writer found the greater part of a buffalo skeleton. It was in a considerably decomposed state, but the skull was still in fair condition, having most of the teeth intact.

Interpretation. (*a*) These remains are probably those of bison that wandered above the usual summer range in their search for forage, and, being overcome by early fall snows, were either frozen or starved to death. About the lake referred to there was excellent forage, which may have attracted bison to this rather unusual altitude. Timber is fairly continuous up to the places where both remains were found, so the bison may have come up through the woods. (*b*) Another interpretation of the skeleton found by the lake is possible: This lake lies at the western opening of a low pass in the Snowy Range, its altitude being 10,800 feet (located in the S.W. $\frac{1}{4}$ of Sec. 34, T. 17 N., R. 79 W.). If any bison attempted to cross the Medicine Bow Mountains, as they no doubt did, this pass would afford the easiest point at which to get across the great barrier, the Snowy Range. Indeed, for a distance of ten miles south of this pass there is no point at which bison could possibly have gotten across.

(3) By far the most interesting discovery was that of bison remains upon the Snowy Range itself, far above timberline. Near the crest of the northern end of the Snowy Range (S. W. $\frac{1}{4}$ of the S. W. $\frac{1}{4}$ of Sec. 4, T. 16 N., R. 79 W.) at an elevation of 11,500 feet the writer found a much decayed bison skeleton. Its members were scattered about among the great quartzite bowlders which here cap the range, but a search

yielded almost all of them. They indicated that the animal was of large but not exceptional proportions. The writer has the horns of this specimen in his possession. Where this skeleton was found, the bowlders are so huge and angular that the writer had to leap from point to point in order to make any progress. How a buffalo could get over a surface of this character to such an astonishing altitude without breaking a limb or becoming entrapped among the bowlders is well-nigh incomprehensible.[5]

Interpretation. There were a few mosses and alpine herbs in places at this altitude, where a little soil had accumulated between the rocks; but these would seem hardly sufficient to attract an animal away from the much better pasturage below up to this dizzy height. The altitude at which these remains were found can not be taken as representing the upper limit at which bison foraged in the Medicine Bow Mountains. Its presence here must be the result of special circumstances. The animal may have been overtaken by early fall snows, become lost, and climbed blindly to this high altitude, where it perished of cold, fatigue, or starvation. It must certainly have climbed the range from either the west or the north, for elsewhere the Snowy Range is bounded by precipitous cirque walls that are practically unscaleable. If it came from the north it probably wandered from the pass across the Snowy Range referred to in (2). Regardless of where it may have come from, the fact that this bison attained such a remarkable altitude over these seemingly impassible slopes testifies to the hardihood and activity of the animal.

(4) The most striking discovery of all was that of two bison skeletons a quarter of a mile south of the point at which that last described was found (location: N. W. ¼ of N. W. ¼ of Sec. 9, T. 16 N., R. 79 W.) at an altitude of 11,650 feet. They lay about fifteen feet apart, within one hundred feet of the brink of a huge glacial cirque, being almost one

[5] The following remarks of Col. R. I. Dodge concerning the mountain buffaloes are very interesting in this connection: "These animals are by no means plentiful, and are moreover excessively shy, inhabiting the deepest, darkest defiles, or the craggy, almost precipitous, sides of mountains inaccessible to any but the most practiced mountaineers." Plains of the Great West, p. 144. Quoted in Hornaday's The Extermination of the American Bison, p. 409.

Dr. Elliott Coues says that "The buffaloes are more expert and venturesome climbers than their unwieldy forms would indicate. Upon the summits of the Sweet Grass Hills, inaccessible on horseback, and where a man can only go about by scrambling, their dung and bones are found, with those of the mountain sheep." Quoted by J. A. Allen, op. cit., p. 541.

thousand feet above timberline and within one hundred fifty feet of the crest of the Snowy Range. These skeletons, too, lay among gigantic bowlders so big that the writer found it difficult to imagine how buffalo, even of the so-called "mountain variety" could possibly get over them.

Both skeletons were practically complete, and were in fine condition; they appeared to be as fresh as are the skeletons of cattle found bleaching on the Great Plains today. The one was that of an average sized animal; the other apparently that of a very big bull, having the largest skull and horns of any the writer has ever found. Being too far from camp at the time to take the heavy skull down, the writer limited himself to one of the horns. It measures 13 inches in outside circumference at the base, 17 inches from tip to base along the outer curve, and 13 inches from tip to base along the inner curve.

An interesting fact was that the tibia and fibula of one leg of the smaller animal were protruding from between two great bowlders. They were so tightly wedged in that only with the greatest difficulty could they be extricated. All the other bones were lying loose around them. Their position strongly suggested that the bison became trapped between the bowlders and, too exhausted to work itself loose, perished there.

Interpretation. The explanation suggested in the case of (3) will also apply here, with the difference that these two animals simply drifted farther and higher than that mentioned in (3) before succumbing. It should be noted, perhaps, that these skeletons were found far above the limits of alpine vegetation, which further indicates that bison whose remains are found on the Snowy Range strayed or were driven far above their normal summer range.

It is quite probable that the two animals perished at the same time, as their skeletons were in the same condition—both far fresher than that described in (3). Their undecayed condition raises the question of whether bison may not have lingered in these mountains long after they were generally believed to be exterminated; the writer found it difficult to believe that these were the skeletons of animals that died more than twenty-five or thirty years ago at the most.

Doctor Hornaday, on the map accompanying his monograph, gives the date when bison were last seen in this part of Wyoming as 1880. J. A. Allen states that "In 1871 . . . . bleached skulls were still frequent in the valley of the North Platte, in western Wyoming, as well as on the Laramie Plains, but I was assured that only stragglers

had been seen in all this region during the previous ten or fifteen years."[6] Elsewhere he says:

> In 1871 no buffaloes occurred in Eastern Wyoming south of the Black Hills, and they had also already been long extinct over the Laramie Plains, and in the valley of the North Platte in Western Wyoming, which region they probably have not regularly frequented since they were dispersed, about 1849–50, by the great overland emigration to California. I was informed that none then existed in the territory south of the Sweetwater Mountains and in the Black Hills. Fremont, in 1842, constantly met with large herds as far west as the Laramie River, but none were seen on the North Platte above the junction of the Laramie until he reached the mouth of the Sweet Water, the grasshoppers and the dry weather having destroyed the grass over the Laramie Plains. An explanation of their final disappearance from the Laramie Plains has been offered by Colonel Richard I. Dodge, which is at least probable. He says that according to hunters' traditions the Laramie Plains were visited in the winter of 1844–45 "by a most extraordinary snow-storm. Contrary to all precedent, there was no wind, and the snow covered the surface evenly to the depth of nearly four feet. Immediately after the storm a bright sun softened the surface, which at night froze into a crust so firm that it was weeks before any heavy animal could make any headway over it. The Laramie Plains, being entirely surrounded by mountains, had always been a favorite wintering place for the buffaloes. Thousands were caught in this storm, and perished miserably by starvation. Since that time not a single buffalo has ever visited the Laramie Plains."[7]

The fresh condition of the two skeletons found on the Snowy Range may possibly be due to the fact that they have been covered by snow perhaps ten months out of the twelve every year.

The work of the writer necessitated his leaving the Medicine Bow Mountains on the day following the discovery of the last two skeletons, and he was therefore unable to continue the search of the top of the Snowy Range for further evidence; he feels confident, however, that such a search would have brought to light additional specimens. He hopes at an early date to return to this region to continue this study and to collect the two skeletons found at the highest altitude. A careful examination and measurement of these may throw light on the question of whether the mountain buffalo differed from his plains relative, as has often, though without satisfactory evidence, been affirmed.[8]

[6] Op. cit., p. 534.

[7] Op. cit., p. 544.

[8] The so-called "wood" or "mountain buffalo" is described by J. A. Allen, op. cit., pp. 447–548 and 545–552. A better and more complete discussion, however, is that of W. T. Hornaday, op. cit., pp. 377, 385, and 407–412.

GENERAL CONCLUSIONS

The field evidence presented above warrants the following generalizations:

(1) During the summer months bison wandered up into the higher mountain regions, the upper limits of their range being largely determined by the limits of their pasturage. In the Medicine Bow Mountains this limit would seem to correspond approximately to timberline, that is about 10,750 feet.

(2) Because of the heavy winter snows in the high altitudes, the bison must certainly have been forced to descend to low altitudes to winter. In the Medicine Bow Mountains they either returned to the Laramie Plains and the plains to the west of the range, or they wintered in the lower mountain meadows between 8000 and 9000 feet.

(3) Under special circumstances, individual animals occasionally wandered above their normal summer range to far higher altitudes, reaching, in the case of the Medicine Bow Mountains, the crest of the Snowy Range, an altitude of 11,650 feet, almost 1000 feet above timberline.

(4) In order to have accomplished the feats of climbing necessary to reach the positions in which their remains were found, the bison that inhabited the mountains must have become adapted to their new environment, developing great hardiness, endurance, and sure-footedness.

(5) It is possible that a band of bison of this sturdy mountain-type lived in the higher altitudes of the Medicine Bow Mountains for some time after they were exterminated in the surrounding country.

The findings and conclusions of the writer, substantially as presented above, were submitted to Doctor Hornaday. His interesting comments are here quoted in part:

> I think that the buffalo remains which you discovered on the Snowy Range at 11,650 feet represent the highest recorded altitude for the wild buffalo. . . .
>
> Your accumulation of high altitude evidence for the American bison makes an interesting contribution to the life history of the species in its wild state. I think that whenever buffalo remains are found at a greater altitude than 7000 feet, which may be set down as the permanent altitude of the small wild buffalo herd that lives in the Yellowstone Park, it may fairly be believed that the animals were migrating, or in search of food in summer, and were caught and frozen to death by the early snows of the summits, which came upon them much earlier than their expectations, and finally engulfed them. It may safely be assumed that no bison could winter at an elevation of even 10,000 feet.
>
> It is entirely possible that a small herd of particularly hardy bison fled to the

Snowy Range and lived there at an elevation of not more then 7000[9] feet for several years, just as the now famous Yellowstone Park band of wild buffaloes manage to do in that reservation. It was as recently as the 24th of last June that I visited the habitat of the buffaloes of the Yellowstone Park, including both the wild bunch and the tame herd. The beautiful La Mar Valley looked to me like a paradise for bison, but instead of remaining in the open mountain pasture, and reveling in its fine grazing possibilities, all the buffaloes had moved up into the heavily timbered summits on the two sides of the La Mar Valley, and were quite swallowed up therein. Bison Warden McComb said that they did so to escape from the flies, but at the time I noticed no flies in La Mar Valley. The present wild bison bunch of the Yellowstone Park is supposed to consist of about 100 head, and there have been no accretions from the captive herd. . . . .

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THE PORCUPINE IN NORTHERN ALASKA

By Olaus J. Murie

On several occasions in various parts of Alaska I have had opportunity to observe interesting feeding habits as well as other characteristics of the porcupine (*Erethizon epixanthum myops*). This animal is widely distributed in Alaska, from the wooded slopes of the Endicott Mountains to western Alaska Peninsula, where alder patches are substitutes for trees. Although generally occurring in coniferous growth, porcupines do live in places far from any heavy forest. In the interior I have found them during the summer seven miles and more beyond the upper edge of woodland while on the Alaska Peninsula they wander even above the alder growth at this season, particularly where rock masses and cavities in bluffs afford them shelter and dens. I have found such places inhabited by porcupines, even where there is scant vegetation.

Spruce bark is universally considered the food of porcupines. This is not, however, their whole diet but may be considered essentially their winter food. In interior Alaska the two spruces (*Picea canadensis* and *Picea mariana*) furnish the principal winter food, but I have found birch trees (*Betula papyrifera*) almost entirely stripped of bark by porcupines. On western Alaska Peninsula alders undoubtedly furnish an important winter food, being practically all that is available for the animals in places. I found alder stems cleanly bitten off at the level of a previous snow.

[9] The lowest altitudes within the Medicine Bow Mountains are 8000 feet.

In summer the animals have a variety of green food, which probably almost entirely replaces the bark. At this season porcupines may be found on the mountain sides, far from woodland, eating grass and her-

FIG. 1

baceous plants. In early spring they eat willow catkins and buds, as I found them doing in 1922 on the Delta River.

I watched one porcupine at close range and was surprised to learn its

method of feeding. This animal climbed into a large willow bush and then began reaching out with a paw for various twigs, bending them within reach of its mouth. Carefully it ran its nose along the twig and, locating each bud and catkin by the scent, nipped it off and ate it. When one twig had been stripped the animal would reach for another. It would promptly bite off any refractory limb that would not bend readily and then, holding it in the paws, proceed to eat the buds and catkins. Sometimes it bent over a limb which it had already stripped of buds, but carefully passed this before its nose, sniffing the length of it to the very tip before letting it go. The deliberate examination of these barren limbs was amusing, since from my position I could see beforehand that they held no buds. During this time I was near enough to see the porcupine's teeth working as they nipped each bud or catkin, yet my presence was never suspected. When the animal felt reasonably sure that no more buds were within convenient reach, having examined some twigs twice, it slowly lowered itself to the ground and sought a new willow.

Early in June of 1921 while hunting bears on the Robertson River, I found porcupines abundant on the river banks and sand bars. Judging by my observations at that time the porcupines were feeding exclusively on mud. I watched many of them, and almost invariably saw that they were licking or chewing the fine sandy soil of the bars or river bank. At a distance of a few feet one could hear the gritting of the sand in the animals' teeth and could plainly see that there was not a vestige of vegetation near. Apparently they stopped for a taste of earth almost anywhere on the bars. Sometimes they would chew up old rotten sticks left stranded by flood waters. Once some rice water, unsalted as I recall it, was thrown out near the tent. A porcupine soon found the spot and busied itself licking and chewing the flavored earth. Parts of the river banks were gnawed and worn, where porcupines, and probably other mammals also, came habitually for a taste of mud. Presumably the porcupines here were obtaining their food in the woods and willow clumps, where they were less conspicuous, and came out on the river bars only for mineral substances. Hence, their actual diet could not be ascertained by these observations.

At this time the pelage of the porcupine was very thin. The finer hair had been shed, only the coarse long hairs and the quills remaining. On many of the animals the lower back was completely devoid of hair, while the quills were not thick enough to conceal the skin. The color varied from fairly dark to whitish, bleached and weathered to several shades.

The porcupine's lack of keen perception was illustrated on many occasions. One of the animals passed close by me once and I followed quietly. At a distance of 50 feet it got my scent, stood for a time with one foot lifted, undecided, and then went on. Presently it spied me as I stood a few feet away, and after a little hesitation waddled up to investigate. For nearly a minute it sniffed about one of my shoes, then ambled on, catching my scent a number of times as I followed, and each time bristling in a defensive attitude. After a time, however, becoming accustomed to me, when it smelled me it would indicate the fact merely by raising the hair of the back a little to expose the quills, but it did not stop.

One day I tried to make a porcupine swim across a narrow stream. I shoved it toward the water with a stick and intercepted it whichever way it turned. Nothing could induce it to swim, although I almost shoved it bodily into the water. It came straight toward me, rather than cross the stream, and I finally gave up the attempt. Yet these animals often swim of their own accord.

I was surprised to find the porcupine awkward in climbing. One that started up a slender birch at my approach had great difficulty, a matter which I could readily appreciate after having climbed several of these smooth-barked trees myself. Slowly and cautiously it would hitch its way up the trunk, using the tail as a prop. The stiff bristles on the under surface of the tail were very useful here.

Another porcupine was forced to take refuge in a large spruce. This time the size of the trunk was a hindrance and the animal was very cautious and painstaking until it finally reached a safe resting place.

The only sounds produced by the porcupines were a combination snort and bark, an unexpected and startling sound heard on two occasions when the animal was approached suddenly; and a moaning sound, heard once, which my companion at first attributed to a cub bear.

In its ordinary activities the porcupine relies largely on its nose. Its hearing seems fairly keen but its sight is poor. It has a general lack of dexterity, resulting from its confidence in the quills for protection against enemies, and from an abundance of food which requires very little skill in obtaining.

The porcupine is cunning enough to make use of its bristling armor. When startled it draws up the skin of the back to expose the quills, and if touched on the hind quarters with a stick, flips its tail back and up in a most effective manner. Finding food, however, is its most impelling urge. The animal's sense of smell appears to have been developed

in seeking its food, while the other senses have deteriorated through limited use.

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THE CARE OF MUSEUM SPECIMENS OF RECENT MAMMALS

By Hartley H. T. Jackson

[*Plate 13*]

The object of the present paper is not to describe general curatorial methods as practiced in various museums nowadays, nor to recite in detail such as are employed in the immense collection of mammals housed in the United States National Museum. We shall, however, note a few of the more important features of some of these methods, as well as consider possible new ones.

There are certain fundamentals in any well-kept mammal collection which we need barely mention. Neatness, accuracy, system and order are absolute essentials. The office of a mammalogist should be as scrupulously neat and orderly as that of any professional or business man and even more so, since dirt is injurious to specimens and disorderliness increases the possibility of all sorts of errors. Specimens not in actual use should be kept inside cases; specimens left on the tops of cases or tables are subject to injury from dust, insects, and other agents. It is well, in a large collection, to have all specimens put away by one individual, who should be held responsible for properly locating each specimen when it is needed. A specimen misplaced is to all purposes a specimen lost. Too much crowding of specimens is destructive, and should be avoided. A damaged specimen should be repaired at once, and any inaccuracies or mistakes *immediately* corrected. Extreme care should be exercised in handling specimens, and each one whether common or rare should be treated as sacred. The common mammal of today may be the rare one of tomorrow, and often a particular specimen is of unexpected value for some particular purpose.

Every museum, large or small, should have a receiving room with facilities for packing, unpacking, and disinfecting specimens. Each shipment when received should be carefully unpacked, and all packing material and boxes thoroughly searched for any possible specimens or fragments left in the waste. The entire collection should then be treated

with a good insecticide (carbon bisulphide fumes will answer this purpose) in order to kill any *Dermestes*, or other pests. If the collection is moldy, as may sometimes happen, particularly if from a tropical region, it is well to dry it thoroughly and treat it with formaldehyde fumes to kill the mold spores. Every effort should be made to keep pests out of the museum offices and laboratories. The collection is now given an accession number and the mammals transferred to the department of mammals.

The shipment of mammals as received by the curator may consist of "made-up skins," raw skins, skulls and skeletons (both large and small), and alcoholics. Each specimen is examined to make certain that it is in good condition, that original catalogue numbers are written legibly and permanently, that skin and skull are properly "matched," and that there are no other irregularities. The specimens are now entered in the museum catalogue of mammals, as far as practicable by genera and species, and in the order of the original numbers. After the museum numbers are placed on the labels, they should be carefully checked and compared with the catalogue to avoid errors. Monel metal[1] tags bearing the catalogue number should be attached by a strong cord to each raw skin which is to be sent to either the tanner or the taxidermist, and a similar tag should be attached with No. 24 Monel wire to each skull larger than that of a squirrel and to each skeleton that is to be sent to the cleaner, and with linen thread to each alcoholic. Smaller skulls and very delicate skeletons should bear tags of very heavy linen paper, on which the number is written with graphite pencil or carbon ink, and attached to the skull by strong linen thread. Skins of animals larger than a badger, raccoon, or fox, except those of rabbits and certain cats which have weak, thin skins, should be tanned. Skins which are to be sent to the tanner should be given code marks, which may be punched in the skins with an awl, and listed to correspond with their respective museum numbers.

We shall now assume that the specimens have been sent to the preparators, there received proper attention, and returned to the department of mammals. Skulls and skeletons have been carefully numbered with India ink; small skulls, up to the size of a red squirrel, placed in homeopathic vials, and larger skulls and skeletons up to the size of a bobcat

[1] Monel metal in its various weights and forms may be obtained from U. T. Hungerford Brass and Copper Company, Lafayette, White and Franklin Streets, New York City. It is a natural alloy of about 67 per cent nickel, 28 per cent copper, and the remaining 5 per cent other metals.

or badger in heavy shouldered pasteboard boxes covered with glazed paper. Skulls and skeletons of mammals larger than a coyote can not be conveniently kept in pasteboard boxes. All should be carefully labeled. Certain skulls and skeletons may need attention at this stage, particularly large skulls. It sometimes happens that in the cleaning process skulls are left with an excess of grease in the bone. Such skulls should be degreased (see Sherman, Journ. Mamm., vol. 6, pp. 182–184, 1925). Or what is more serious, a skull may have been treated with too strong alkali or boiled in the cleaning to such an extent as to extract *all* oil from the bone, making it crumbly and brittle. Such a skull should be soaked for several hours in melted paraffin (see Boettcher, Proc. U. S. Nat. Mus., vol. 41, pp. 697–705, 1912). Either excessive grease or excessive dryness spells destruction of the skull. Certain teeth are prone to split, crack, or chip after the skull has been cleaned and stored in the collection. The canines and molars of the larger carnivores and the incisors and molariform teeth of ungulates are particularly so inclined. To prevent this, such teeth should be coated with a thin solution of Ambroid cement.[2]

Each skin and skull now properly matched and labeled, the specimens are ready for identification, and installation in the collection. A card catalogue is almost a necessity in a large collection, and each specimen before being put away permanently should be carded. A preferable style of card is one 4 by 6 inches which allows for 12 entries on the card (Fig. 1). At the upper left hand corner of the card is the generic, specific, and subspecific name, followed on the line below by the state or province, and on the next line by the definite locality; each specimen from this locality is allotted a following line, with entries of museum number, sex, date, collector, original number, and remarks, the entries being made in the order of the catalogue numbers. The system may be extended further by indicating on the card the location of the specimen in the collection. As a convenience in finding references to specimens from certain regions, differently colored cards may be adopted for major geographic regions, as is done in the Field Museum of Natural History.

Ideal conditions require that the entire collection be stored on the

[2] In our Biological Survey laboratories we dilute one part of commercial ambroid with one or more parts of the solvent supplied by the manufacturer. Ambroid and the solvent may be obtained from the Ambroid Company, 227 Miller Avenue, Brooklyn, N. Y., but is now on the shelves of most up-to-date hardware stores.

same floor as the offices and laboratories. Individual preferences determine whether small skulls shall be kept with the skins or not. Personally I prefer to keep all skulls separate from the skins. I never compare a skull with a skin, or vice versa! However, if a collection is scattered all over an 8-acre lot and on several floors ranging from a basement to an attic, there is some advantage in having skins and their corresponding skulls together. Made-up skins, small skulls (whether kept with the skins or separate), and larger skulls up to the size of a bear or larger if without horns or antlers, are best stored in specimen cases.

Perognathus intermedius intermedius — Mapped

ARIZONA

Grand Canyon

202444	♂	Aug. 22, 1913	E. A. Goldman	22143	Indian Gardens	4800 ft.	
202445	♂	"	"	22144	"	"	"
202446	♂	"	"	22145	"	"	Skull only
215486	♂	Sept. 12, 1916	W. P. Taylor	1144	S. side 6 mi. N. Bass Camp	3000 ft.	
215487	♀	"	"	1145	"	"	Alcoholic
215488	♂	13	"	1147	"	"	3500 ft.
215489	♂	"	"	1148	"	"	"
215725	♂	"	H. H. Jackson	655	"	"	"
215726	♂	"	"	656	"	"	"
215727	♀	"	"	657	"	"	"
215728	♀	"	"	658	"	"	Skeleton

FIG. 1. COPY OF SPECIMEN CARD USED IN U. S. BIOLOGICAL SURVEY
Reduced from 4 x 6 inches

Here again, in the choice of a storage case, individual preference plays a part. Some still cling to the Cambridge can as if it were a life-preserver. Others prefer a cumbersome heavy steel case, impracticable to move and very expensive. In my estimation there are no better cases than the standards now used in the U. S. National Museum. These are moderate in cost, vermin proof, and reasonably fire- and dust-proof. They are made in three sizes, multiples of each other, known as quarter-unit, half-unit, and unit size.

Space does not permit of a detailed description of these cases here,

but the illustration of the quarter-unit case (Plate 13) gives a rough idea of its construction. The case is made of a strong wooden frame covered with sheet iron which may be painted any color to suit one's taste. We use white in the National Museum collection of mammals in order to facilitate lighting effect. The quarter-unit case measures 39½ inches high by 39 deep by 28½ wide outside; the half-unit measures 39½ inches high by 39 deep by 57 wide. Each drawer of the quarter-unit case measures 36 x 24 x 2 inches outside, and 34½ x 22½ x 1½ inches inside. These cases could be improved by making the *inside* of the drawer of the quarter-unit size a measurement of 24 x 36 inches instead of such a measurement for the outside of the drawer, and then basing the other sizes on this as a standard. The reason is obvious; it is desirable to have a drawer of dimensions *easily* factored, so as to accept various sizes of pasteboard trays without waste space in the drawer. Skins and skulls should be neatly and systematically arranged in glazed cardboard trays in the drawers, and a 3 x 5 inch card should be placed in each tray to indicate the contents.

The storage of big-horned or antlered skulls is more complicated. Apparently they are best stored in dust-proof rooms, where they can be suspended in a horizontal row between two parallel rods which support the skulls at the base of the antlers. Tanned skins should also be kept in dust and vermin-proof rooms, where they may be suspended from iron rods by loops of cords passed through the skin above the rhinarium and attached to the rod with an S-hook. Before permanent installation in the collection each skin after it is tanned should receive attention from the taxidermist in order to relax misshapen ears, feet, and the like. The museum number should be written in carbon ink on the inside of the skin.

The fight against *Dermestes* and other vermin is one of the great worries of a curator of mammals. The use of carbon bisulphide in cases is effective, but is not satisfactory on account of the danger from fire or explosion. Paradichlorobenzine,[3] when used continuously in sufficient quantities, will keep moths and *Dermestes* away and will prevent their feeding when present, but to some persons the odor is sickening. Carbon tetrachloride has much the same effect on vermin as paradichlorobenzine, but is less desirable, in that it is liquid. Mr. Gerrit S. Miller, Jr., has experimented with paradichlorobenzine, and the writer with carbon tetrachloride, and we find that when numerous healthy *Dermestes*

[3] Paradichlorobenzine, under the commercial name paracide, may be obtained from the Hooper Electrochemical Company, 25 Pine Street, New York City.

larvae and adults are confined with an abundance of food in a storage case in which either of these chemicals has been placed the insects leave the food and strive to find exit from the case by seeking cracks and corners which might offer them opportunity for escape. Here they remain and starve to death. Hydrocyanic acid gas is very effective against all pests, but it can be used only in tightly closed rooms and its excessive toxicity makes its use undesirable except in special cases. The mixture of ethyl acetate and carbon tetrachloride in proportion of four to six by volume as recently described for killing weevils in grain cars by Doctor Back (Journ. Econ. Entomology, vol. 17, p. 663, 1924) might also prove an effective fumigant for museum use.

However, the use of poisons, whether solid, liquid, or gaseous, is never satisfactory, and if museums were properly constructed the use of such insecticides could almost be eliminated. By the same process that we could eliminate these obnoxious chemicals, we could increase the life of our specimens, whether skins, skulls, or alcoholics. As the remedy I suggest the use of constant temperature rooms. Such rooms are entirely practicable, not expensive to construct, and reasonably cheap to operate. The rooms containing skins (whether tanned or "made-up") and alcoholics should be maintained at a temperature of about 50°F. Moths and *Dermestes* will not work or breed at this temperature. Each of these rooms should be cork-lined, windowless, and essentially air-tight, except for the air supplied through the ventilator. Such air should be passed through glass wool and either sulphuric acid or calcium chloride or both, in order to clean and dry it. The cooling is accomplished by a coil at the ceiling, which is supplied with ammonia from a museum ice-machine. An automatic valve in the pipe would regulate the temperature in the room. The rooms in which skulls are to be stored should be maintained at a higher temperature than that of the skin and alcoholic rooms, say about 70°F. It is the contraction and expansion due to falling and rising temperatures that is detrimental to teeth and bones; and contraction is more harmful than expansion. A sudden drop of temperature acts much the same on a tooth as on cut glass. By coating the teeth with dilute Ambroid cement and keeping skulls at a temperature which is constant but not too low, much of the destruction of teeth and skulls can be avoided.

U. S. Biological Survey, Washington, D. C.

QUARTER-UNIT STORAGE CASE USED IN U. S. NATIONAL MUSEUM FOR MAMMAL SKINS AND SKULLS

Note the detachable door with insecticide holder conveniently placed on inside, and the window-catches which draw the door tightly against poisoned felt on the door-casing to prevent the entrance of pests and dirt.

UNIV OF MICH

THE COPULATION PLUG AND THE ACCESSORY GENITAL GLANDS OF MAMMALS

By Earl Theron Engle

The existence of a rigid plug which completely fills the lumen of the vagina of certain mammals after completed ejaculation has been known for nearly seventy-five years. During this period it has been observed to be a constant phenomenon in eleven genera among four mammalian orders.

The first recorded observation of the plug is that of Leuckart (1847) with the guinea-pig. He suggested that it was formed by the secretion from "a pair of contorted tubes," undoubtedly meaning the seminal vesicles. Later (1853) Leuckart concluded that the plug was formed by the mixing of the prostatic secretion with that of the seminal vesicles. The same year Bischoff (1853) confirmed the observations of Leuckart. Later Lataste (1882 and 1883) investigated the occurrence of the "bouchon vaginale" in several genera of rodents including *Pachyuromys duprasi*, *Dipodillus simoni*, *Meriones shawi*, *Cavia cobaya*, and *Mus musculus*. He concluded that the formation of the copulation plug was due entirely to the secretion of the seminal vesicles. Camus and Gley (1896–1900) carried the work further, and concluded that the coagulation was caused by the action of an enzyme present in the prostatic secretion. This they called "vesiculase." Recently (1922, a, b) these authors have observed plug formation in the jerboa (*Dipus* sp.) and in an Argentine rodent, *Viscacia viscacia*. A more extended historical summary is found in Stockard and Papanicalou (1919).

Walker (1910, a, b) advanced the view that the entire prostate in the rat and the guinea-pig is not concerned in secreting the ferment which coagulates the vesicular secretion, but that this enzyme is derived from paired prostatic lobes lying in the same fascial sheath as the vesiculae seminales.

The experiments of Walker, together with further experiments, were repeated on the guinea-pig by the writer (Engle, 1926) and confirm the view that the proximal pair of the three pairs of lobes of the prostate is the only source of the activating substance which coagulates the vesicular secretion. On the basis of histological differences between the proximal and the distal and the intermediate lobes, Walker regarded the proximal lobe as a distinct organ, the "coagulating gland."

The embryological evidence found by the writer does not confirm this position. The so-called "coagulatory gland," more properly the proxi-

TABLE 1

	SEMINAL VESICLE	PROSTATE	BULBO-URETHRAL GLANDS	AUTHORITY
Monotremata:				
Ornithorhynchus	Absent	Lacking	One pair	Home, 1802
Echidna	Lacking	Lacking	One pair	Home, 1802
Marsupialia:				
Macropus sp.	Lacking	Numerous glands in urethral bulb	Three pairs	Broek, 1910
Caenolestes obscurus	Lacking	Very large single	Three pairs	Osgood, 1921
Didelphis v. virginiana	Lacking	Disseminata	Three pairs	Engle, unpubl.
Other marsupials	Lacking	Unknown	One to three pairs	Disselhorst, 1904b
Insectivora:				
Erinaceus europæus	Lacking	Three large pairs	Two pairs	Rauther, 1903a
Tupaia ferruginaea	One pair	One pair		Wood-Jones, 1917b
Talpa europæa	Lacking	One large pair	One pair	Rauther, 1903a
Chiroptera:				
Pteropus edwardsi	One pair	One pair	One pair	Oudemans, 1892
Vesperugo pipistrellus	"glandula ampullarum"	One pair	One pair	Rauther, 1903b. See also Disselhorst, 1904a
Carnivora:				
Canis familiaris	Lacking	Unpaired gland	Lacking	Sisson, 1911
Felis domestica	Lacking	Two pairs	One pair	Schmaltz, 1911
Felis leo	Lacking	One pair	One pair	Oudemans, 1892
all Mustelidae	Lacking	Present	Lacking	Oudemans, 1892
Pinnipedia:				
Trichechus rosmarus	Lacking	resent	Lacking	Murie, 1872
Otaria jubata	Lacking	resent	Lacking	Murie, 1872
Phoca vitulina	Lacking	Present	Lacking	Oudemans, 1892

*Primates:**				
Lemuroidea	One pair	One body	One pair	Oudemans, 1892
Chiromys madagascariensis	Lacking	One body	One pair	Oudemans, 1892
Aye-aye	Lacking	One body	One pair	Owen, 1862
Lemur vapi	One pair	One body	One pair	Oudemans, 1892
Anthropoidea:				
Macacus nemestrinus	One pair	Two parts	One pair	Oudemans, 1892
Other Anthropoids	One pair	Two lobes	One pair	Oudemans, 1892
Homo	One pair	Two lateral, one middle	One pair	
Pan	One pair	Two lateral, one middle	One pair	Sonntag, 1923
Rodentia:				
Mus, all species	One pair	Three pairs	One pair	Rauther, 1903a
Rattus norvegicus	One pair	Three pairs	One pair	Rauther, 1903a
Cavia cobaya	One pair	Three pairs	One pair	Rauther, 1903a
Sciurus vulgaris	One pair	Lacking	One pair	Grosz, 1905
Lagomorpha:				
Lepus cuniculus	Lacking	"Paraprostate"	At least three glands	Rauther, 1903a
Artiodactyla:				
Sus scrofa	One large pair	Two parts	One pair	Sisson, 1911
Dicotyles torquatus	One pair	One body	One pair	Oudemans, 1892
Ovis aries	One pair	Disseminata	One pair	Schmaltz, 1911
Bos taurus	One pair	Two parts	One pair	Sisson, 1911
Nubian giraffe	Not stated	Two glands	Not stated	Owen, 1868
Hippopotamus amphibius	One pair	Disseminata	One pair	Hofmann, 1923
Auchenia lama	Absent	Present	One pair	Oudemans, 1892

*For additional data the papers of Klaar and Krasa, 1921, and Mijsberg, 1923, may be consulted.

TABLE 1—*Concluded*

	SEMINAL VESICLE	PROSTATE	BULBO-URETHRAL GLANDS	AUTHORITY
Perissodactyla:				
Equus caballus	One pair	"Two lateral lobes, isthmus"	One pair	Sisson, 1911
Rhinoceros indicus	One pair	Present	Not stated	Owen, 1862
Ceratorhinus sumatraensis	One pair	One body (?)	Not stated	Forbes, 1881
Tapirus americanus	Paired	Two pairs	Present	Hofmann, 1923
Xenarthra:				
Manis javanica	One pair	Two pairs	Absent (?)	Oudemans, 1892
Bradypus tridactylus	Rudimentary	"disseminata"	One pair	Klinkowström, 1895
Dasypus spa	Absent	One large gland	One pair	Klinkowström, 1895
Myrmecophaga jubata	Rudimentary	Present	One pair	Klinkowström, 1895
Proboscidia:				
Elephas indicus	One pair	Two pairs	One pair	Watson, 1872
E. africanus	One pair	One pair	One pair	Hofmann, 1923
Sirenia:				
Halicore dugong	One pair	One body	Lacking	Riha, 1911
Hyracoidea:				
Hyrax capensis	One pair	Several lobes	One pair	Oudemans, 1892
Cetacea:				
Phocaena phocaena	Lacking	Paired	Lacking	Daudt, 1898
Beluga leucas	Lacking	Present	Lacking	Daudt, 1898
Sibbaldus musculus	Lacking	Present	Lacking	Daudt, 1898

mal prostate, develops in the same manner and from the same anlage as the remaining two lobes; its duct is continuous with that of the intermediate lobe until shortly before birth. From this embryological evidence it is evident that the "coagulating gland" of Walker should be considered as a morphological unit of the prostate gland.

The occurrence of a copulation plug is not confined to rodents for it is present in several widely separated orders. Hartman (1924) records the occurrence of the plug in the opossum (*Didelphis virginiana virginiana*) but offers a different opinion as to its formation, saying that "the plug is not derived entirely from the male organs, but consists rather of the fluid of the lateral vaginal canals, coagulated under the influence of the seminal fluid." Hartman added that "the plug represents the contents of the lateral vaginal canals plus semen." In the guinea-pig, however, the secretion of the female genital tract has no part in the formation of the copulation plug. A vaginal plug apparently occurs also in the Chiroptera for Wood Jones (1917) wrote: "The cervical secretion (of the uterus), possibly under the influence of the prostatic secretion in the seminal fluid, entirely plugs the female genital passage with a mucous 'bouchon'."

A plug also has been found in the hedgehog, *Erinaceus europaeus*, by Gley (1899) although the glands concerned in producing the coagulation are still undetermined owing to the confused state of both the nomenclature and the homology of the accessory genital glands. Gley stated that Cowper's glands in the hedgehog elaborate the ferment which causes coagulation of the secretion of the seminal vesicles.

Rauther (1903) and Disselhorst (1904a) made careful studies of the accessory genital glands, and agree as to structural details. Rauther concluded that there are no vesiculae seminales in *Erinaceus* but three pairs of prostatic lobes. Disselhorst (p. 181) says regarding this matter "Denn die sogenannte Samenblase des Igels mündet nicht in den Samenleiter (und das ist die morphologische Voraussetzung zu dieser Bezeichnung), sondern in den Canalis Urogenitalis." Linton (1907) considered these glands to be neither bulbo-urethral (Cowper's) nor prostatic, and held that they should be considered *sui generis* until embryological evidence is obtained. However, that an entirely new structure should appear in this genus is not in accord with present concepts of morphology, although it may be said that there is some evidence that the Cowper's glands of the opossum, and perhaps of all the Marsupialia, are not true bulbo-urethral glands.

The copulation plug is not known to occur in other animals than the

ones cited above, but it is reasonable to surmise its occurrence in some other mammals. Since plug-formation is dependent upon one or more of the accessory genital glands, a summary of the literature dealing with these glands is given in Table I. Since I have not covered all the literature, these organs may be mentioned in other works. The arrangement of orders in the table follows that of Miller (1923). The genus and species is that of the author quoted, without correction in regard to synonymy.

The seminal vesicles occur in eight of the sixteen orders listed here. The insectivores are not included in the eight, although Wood Jones (1917b) records *Tupaia* as possessing seminal vesicles. In his description he states that it is difficult to distinguish the seminal vesicles from the paired prostate gland in a gross examination. Since he does not publish figures of the microscopic anatomy of the glands in question, and since other insectivores have been shown by Rauther (1903a) to have no seminal vesicles, it would seem better to regard the matter as undecided.

With a few exceptions the prostate has been found in all of the species above the monotremes. One noticeable exception is that of *Sciurus vulgaris*, which is stated by Grosz (1905) to possess seminal vesicles but no prostate. Such an exception occurring in an order in which many species are known to possess a compound prostate is very unusual. In his discussion of the Cervidae, Oudemans (1892) states that the prostate is lacking in this family. His diagrams of the urogenital tract in this group, and our knowledge of the Bovidae, suggest the possibility that the prostate, as in the buck and the ram, is of the disseminate type, and is not immediately apparent on dissection.

That these accessory genital glands and the copulation plug are of some significance for systematic mammalogy, as well as for life history studies, is scarcely to be doubted. It is to be hoped that more complete observations on American mammals will supply the present lack in this regard.

This paper represents a portion of a study of the prostate gland of the guinea-pig undertaken at the suggestion of Doctor Meyer, and under his direction. I am greatly indebted to him also for a reading of the manuscript.

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A NEW MARTEN FROM THE PLEISTOCENE CAVE DEPOSITS OF CALIFORNIA

By E. Raymond Hall

[*Plate 14*]

In a study of certain Recent and fossil Mustelidæ an examination has been made of the mustelid remains from the Pleistocene cave deposits of California. One of the most interesting results of the examination of this material is the discovery of what is believed to be a new form of the genus *Martes* in the collections from Samwel and Potter Creek caves, which genus has not hitherto been reported from the two caves unless the mention of *Mustela* sp. from Samwel Cave by Furlong (Amer. Journ. Sci., 1906, Ser. 4, **22**, 245) and by Stock (Univ. California Publ., Bull. Dept. Geol., **10**, 469) have reference to this form.

Acknowledgments are made to Prof. Chester Stock and Mr. W. L. Furlong of the Department of Geology for assistance in the study of the collections from the cavern accumulations and to Prof. Joseph Grinnell for the use of Recent material under his charge in the Museum of Vertebrate Zoology.

Martes caurina nobilis new subspecies

Type.—Right maxilla lacking canine and Pm^1, no. 9835, Univ. California Mus. Paleo. Coll., Pleistocene deposit, Samwel Cave, Shasta County, California.

Referred material.—2 left lower jaws, nos. 9014 and 9389 from Samwel Cave; 1 right lower jaw, 3 left lower jaws, all incomplete, and 1 left maxilla bearing M_1 from Potter Creek Cave, Shasta County, California.

Diagnosis.—Distinguished by deep horizontal ramus, great antero-posterior extent of coronoid process, crowded premolars, and generally large size of teeth, lower jaws and known parts of the cranium (see table for actual dimensions).

Comparison.—In the type and in no. 8348 the great expansion of the inner half of M^1 and, in the lower jaw, the proportions of M_1 and great depth of the horizontal ramus at the anterior border of M_1 show the closer relation to *Martes caurina* (Merriam) than to any of the other described species.

The incisors are preserved in none of the Pleistocene specimens. No. 9014 only, has the canine preserved. Probably 2 mm. of the tip is broken off. Measurements taken at the alveolus show the antero-posterior diameter at this place to be the same as in the largest of the Recent specimens, but it differs from any Recent specimen examined in being slightly heavier except at the place where it emerges from the alveolus.

Pm_1 is not preserved in any of the Pleistocene specimens, but the alveoli show it to have been small, single rooted, and occupying a small space in every case where present. It is absent in no. 9389 U. C. P. C. It is absent also on one

side in two specimens of *M. c. sierrae* Grinnell and Storer and on both sides in two other specimens of *M. c. sierrae*.

Nos. 5607, 8727 and 9389, have both Pm_2 and $_2$ preserved and show these teeth to be more crowded than in Recent specimens. Otherwise, except for slightly greater average size, no special differences in the premolars, not covered by individual variation in Recent specimens, are to be seen.

M_1 has the greatest length in no. 8237, 11.1 mm. This is 0.6 mm. longer than

TABLE 1

	CATALOGUE NUMBER		LENGTH OF M_1	WIDTH OF M_1 ACROSS PROTOCONID	GREATEST WIDTH OF M_1 ACROSS HEEL	ANTERO-POSTERIOR DIAMETER OF CANINE AT PLANE PASSING ACROSS TIPS OF INCISORS	DEPTH OF MANDIBLE AT POSTERIOR BORDER OF M_1	DEPTH OF MANDIBLE AT ANTERIOR BORDER OF M_1	GREATEST LENGTH OF MANDIBLE	TIP OF CORONOID PROCESS TO TIP OF ANGULAR PROCESS	ANTERO-POSTERIOR DIAMETER OF CORONOID PROCESS AT BASE
M. c. nobilis.....	8237	U. C. P. C.	11.1	4.1	4.2		11.2	10.2			
M. c. nobilis.....	9014	U. C. P. C.				3.9	10.9	8.7	56.9	26.0	14.0
M. c. nobilis.....	9389	U. C. P. C.	10.5	4.0	4.2		11.3	10.2	56.8	26.3	14.6
M. c. nobilis.....	8727	U. C. P. C.	10.0	3.6	3.8		9.5	7.8	51.8		12.3
M. c. nobilis.....	8394	U. C. P. C.	11.0	3.9	4.0		10.4	9.4			14.0
M. c. nobilis.....	5607	U. C. P. C.	9.8	3.6	4.1			8.1			
*M. caurina**.....	13773	M. V. Z.	10.5	3.8	4.1	3.4	10.2	8.9	55.0	24.8	12.9
M. c. sierrae.....	24822	M. V. Z.	10.5	3.7	4.1	3.3	9.5	7.8	54.0	24.4	12.0
M. c. caurina.....	1063	S. G. Jewett coll.	9.5	3.6	4.0	3.4	9.5	8.3	55.3	24.6	12.8
M. c. vancouverensis.....	12472	M. V. Z.	10.0	3.5	3.7	3.4	9.6	8.4	57.2	25.0	12.9

No. 5607 represents a young individual.

* Regarded as intermediate between *M. c. caurina* and *M. c. sierrae*.

in any of the Recent specimens of *M. caurina*. This tooth is equal in size to that of a small female specimen of *Martes pennanti pacifica* (Rhoads) with which it was compared. That the specimen belongs to the subgenus *Martes* and not to the subgenus *Pekania* is shown by the short distance between the posterior margin of M_2 and the anterior base of the coronoid process, the greater relative width of the heel of M_1, the extension of the masseteric fossa to a point well under M_2, the greater depth of this fossa, and the corresponding sharper demarcation of its borders. In no. 9014 the two alveoli of M_1 are well preserved and show the tooth

to have been 10.6 mm. long at this place. From analogy with other specimens, the greatest length of the tooth is believed to have been 11 mm. or more. The metaconid is not more developed than it is in *M. c. caurina* or in *M. c. sierrae*, if as much.

The coronoid process is heavier in *M. c. nobilis* than in *M. c. caurina* or in *M. c. sierrae*. The depth of the horizontal ramus, especially at the anterior border of M_1, is relatively as well as actually heavier in *M. c. nobilis* than in the other two previously mentioned forms. No. 9014 appears to be an exception in that the corresponding measurement is greater in two of the Recent specimens. This is partly due to the fact that some of the ventral border, and more of the dorsal

TABLE 2

	CATALOGUE NUMBER		WIDTH OF M^2 (MEDIO-LATERALLY)	GREATEST LENGTH OF INNER HALF OF M^2	GREATEST (EXACTLY TRANSVERSE) LENGTH OF OUTER HALF OF M^2	LENGTH OF Pm^4	WIDTH (DIAGONALLY) OF Pm^4 ACROSS PARACONE AND METACONE	POSTERIOR BORDER OF ALVEOLUS OF CANINE TO POSTERIOR BORDER OF M^1	PARS FACIALIS TUBERCLE TO ALVEOLUS OF ANTERIOR ROOT OF Pm^4
M. c. nobilis	9835	U. C. P. C.	9.9	6.0	4.0	9.6	6.4	25.2	15.0
M. c. nobilis	8348	U. C. P. C.	9.6	6.4	4.3			25.6	15.0
*M. caurina**	13773	M. V. Z.	9.4	5.7	4.1	9.0	5.8	24.7	13.4
M. c. sierrae	24822	M. V. Z.	8.8	6.0	4.1	9.0	6.2	24.4	13.1
M. c. caurina	1063	S. G. Jewett coll.	8.6	5.5	4.1	8.4	5.2	24.0	14.5
M. c. vancouverensis	12472	M. V. Z.	8.7	4.7	3.9	8.7	6.0	24.6	13.7

* Regarded as intermediate between *M. c. caurina* and *M. c. sierrae*.

border, of the horizontal ramus were scraped away in freeing the lateral surface of the specimen from the incrustation in which it was contained. The depth was certainly more than 8.3 mm. Even so it was probably less than in other examples of *M. c. nobilis* of otherwise equal size.

With the exception of the length of M^1 the type of *M. c. nobilis* is larger in every part measured than the largest of the Recent specimens. It is also more importantly distinguished by the crowded condition of the premolars. Although Pm^2 is partly broken away in this specimen the posterior half occupies the original position in which the heel is back of and lateral to the anterior portion of Pm^3 to a greater extent than in any Recent specimen examined (see fig. 1). The alveolus of Pm^1 also shows this tooth to have been much crowded. No. 8348 U. C. P. C., as

may be seen from the measurements, has nearly the same size and proportions as the type.

M. c. nobilis is distinguished from all other described North American Recent forms, except perhaps *M. brumalis* (Bangs) (no specimens, adequate descriptions or figures of lower jaws of this species have been seen), by the relatively deeper horizontal ramus, greater antero-posterior diameter of coronoid process, more massive canine and more crowded premolars. *M. c. nobilis* is much smaller than *Martes diluviana* (Cope). While the premolars are more crowded in *M. c. nobilis* than in Recent forms, they conform to the *caurina* type in being narrower than in *Martes nesophila* (Osgood), but broader than in *Martes americana* (Turton) and related species. So far as can be judged from descriptions, *M. c. origenes* (Rhoads) differs from the new form in about the same way that *M. c. caurina* does. In several respects *M. c. sierrae* differs from *M. c. caurina* in the same direction as does *M. c. nobilis*. For instance, *M. c. sierrae* appears to stand between *M. c. caurina* and *M. c. nobilis* in degree of development of crowded dentition, size of M_1, depth of horizontal ramus, and antero-posterior diameter of coronoid process. On the other hand *M. c. nobilis* appears to have been more like *M. c. caurina* in possessing a high frontal region.

Each of the four Recent skulls, whose measurements are here given for comparison with those of *M. c. nobilis*, is the largest adult male in the respective series of skulls representing its kind that is available for comparison. The several series include 6 skulls of *Martes c. vancouverensis* from Vancouver Island, B. C.; 6 skulls of *Martes caurina caurina* from Skagit Valley, British Columbia, 4 miles north of international boundary; 7 skulls of *Martes caurina* from Trinity and Siskiyou counties, California, regarded as intergrades between *M. c. caurina* and *M. c. sierrae*, although more nearly related to the latter; and 19 skulls of *Martes caurina sierrae* from various localities in California.

Remarks.—The specimens from Trinity and Siskyou counties, California, that are not typical of *M. c. sierrae* and that tend toward *M. c. caurina*, approach closer to the new form than do any other Recent specimens examined. Two Recent specimens are also available from Shasta County, but are clearly referable to *M. c. sierrae*.

Judging from the morphologic characters presented by the Pleistocene form, it is clearly related to the martens inhabiting north-central California to-day and might well be regarded as belonging in or near the group from which the modern forms of the region have taken their origin. The presence of living martens in the region of the cave deposit coupled with the fact that only slight structural differences exist between the Recent and Pleistocene forms strongly suggest such relationship.

On the other hand, *M. c. nobilis* may have become extinct without giving rise to any subsequent race or it may be actually represented in the Recent fauna by some undescribed subspecies. The latter possibility seems highly improbable, however, since specimens from practically all well defined faunal areas contiguous to the cave region have been examined.

Museum of Vertebrate Zoology, Berkeley, California.

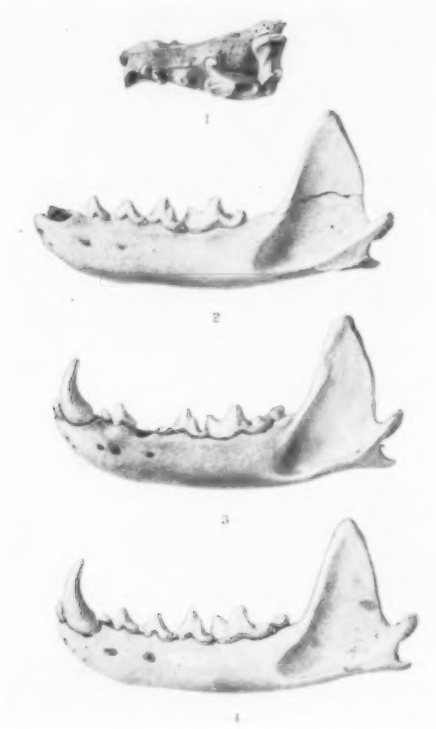

Fig. 1. Martes caurina nobilis, Type, Right Maxilla, No. 9835 U. C. Mus. Paleo. Coll.; Samwel Cave, Shasta County, California

Fig. 2. Martes caurina nobilis, Left Lower Mandible, No. 9389 U. C. Mus. Paleo. Coll.; Samwel Cave, Shasta County, California

Fig. 3. Martes caurina, Intermediate between M. c. caurina and M. c. sierrae, Left Lower Mandible, No. 13773 M. V. Z., ♂; Trinity County, California

Fig. 4. Martes caurina vancouverensis Grinnell and Dixon, Left Lower Mandible, No. 12472 M. V. Z., ♂; Vancouver Island, British Columbia

Comparison of figure 2 with figures 3 and 4 shows, among other things, the heavy horizontal ramus and great antero-posterior diameter of the coronoid process of *M. c. nobilis*. The premolars are less crowded in no. 9389 than in any other of the Pleistocene specimens, thus not being typical in this respect. The crowded condition of the premolars and generally large size of the type may also be noted. All figures natural size.

UNIV. OF MICH.

GENERAL NOTES

WHAT IS THE NORTHWARD LIMIT OF RANGE FOR THE MASTIFF BAT?

The current records of the distribution of the California mastiff bat (*Eumops californicus*) indicate the range of the species as being within the Lower Sonoran Zone. Mrs. Grinnell (University of California Publ. Zool., vol. 17, 1918, p. 373) gives Fresno and Mendota as the northernmost stations of occurrence, both based upon specimens.

During June, 1925, while collecting in Lake County, I made the acquaintance of Mr. J. B. Maker of Middletown, who has lived in various parts of Lake County for about thirty years. He told me of once finding in the valley near Middletown a large bat which measured sixteen inches in total spread of wings. There were no notable features of color. None of our other California species is believed to have a spread exceeding twelve inches. As I found Mr. Maker to be reliable and conservative on many other observations which he repeated to me, I am inclined to accept his report of the size of this bat.

In August, 1925, Mr. Warner Wilson of Davis told me that a relative, Mr. Alex Kennedy, who lives in the mountains east of Clear Lake, near Arabella, Lake County, had recently killed a large bat, the description of which accorded with that of the mastiff bat. The specimen was not saved, and a search, in the place where it had been shot, failed to reveal any trace of it. Mr. Wilson is quite familiar with the various species of bats occurring commonly in northern California, having made a considerable collection of them; at the time when he told me of the above, he was unaware of my having any other information on the subject.

It is unfortunate that no specimens are at hand to substantiate the above circumstantial accounts of the mastiff bat in Lake County. Both of the residents mentioned have been told of the desirability of saving any subsequent specimens which they may find. In the meanwhile it seems desirable to publish these notes so that mammalogists may be on the watch for the species in more northern localities.—Tracy I. Storer, *Zoological Laboratory, University Farm, Davis, California.*

SKUNK EATS KITTENS

In early December, 1925, J. D. Lamb missed three kittens out of a litter of five living on his farm near Manchester, in Washtenaw County, Michigan. A few days later a trapper dug out a skunk den on the farm and in the burrow found the partly eaten remains of two kittens, one of which could be positively identified as being one of those missed by Mr. Lamb. The kittens were over half-grown, and they must have been carried about 400 yards to the den. No remains were found of the third kitten. The species of skunk is *Mephitis nigra.*—L. R. Dice, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

STRENGTH OF CHIMPANZEES

J. E. Bauman's article in the last issue of the Journal of Mammalogy (February, 1926) on this topic is exceedingly interesting, making one marvel at

the vast strength displayed by these primates, and causing one to wonder over the cause of such a great gulf between their muscular power and that of another primate, man, a gulf clearly demonstrated by the data given in Bauman's report. His report suggested several possible causes for the difference he speaks of, and he logically points out that it is the physiologist's work to explain it.

Attention is invited to the possibility that this difference in muscular power between these two species of primates may be due in part, or altogether, to difference in efficiency and force in the *endocrines* of the two species. While it is far from settled that some ductless glands are motor excitors and stimulators, no one is ready to hold that these glands are not at all correlated with the muscular system. Here is where findings in clinical medicine and in human pathology shed some light on the question so interestingly presented by Bauman.

Any one who has seen a case of myxoedema (hypo-thyroid action), or a man with Addison's disease (adrenal insufficiency), and has noted the concomitant muscular torpor or weakness, or an individual suffering from over-activity of the thyroid (hyperthyroidism) and his muscular excitability, can realize that these glands in some way have some influence, directly or indirectly, on the muscular system.

It is conceivable that chimpanzees have, relatively at least, larger and more active endocrines than has man, a possibility which may be a factor in what, in all probability, is a poly-phase question. It certainly does come back to the physiologist, and perhaps also to the anatomist, to investigate this side of the possible causes of a chimpanzee's enormous strength.—W. H. Bergtold, *Denver, Colorado.*

TREE-CLIMBING WOODCHUCKS AGAIN

In the Minnesota National Forest, especially throughout the coniferous parts of it, woodchucks are common and can be seen almost daily by anyone who wanders leisurely along the trails. On a sunny afternoon of the past summer (1925), when I was walking slowly along an old tote-road, a woodchuck was sighted sitting in the crotch of a limb about six feet from the ground on the sunny side of a jack pine which was about nine inches in diameter. Curious to know what the woodchuck was doing and what his tactics might be if disturbed, I slowly approached to investigate, all the time in full view of the animal. He made not the slightest move until I was within about six feet of the tree. Then he turned clumsily and, to my surprise, even more clumsily and apparently with difficulty clawed his way, not down, but about four feet higher up the tree. There he stopped and clung rather insecurely to the bark. It seemed as though his strength gave out at this point, and I was interested to see how long he could manage to hold on in that ascending position. After the lapse of a few minutes he began to turn his head right and left as if pondering over the next move. But he continued to cling fast. Not having much time at my disposal, I picked up a small stick and threw it at him. My aim was poor but the effort started him a couple of feet higher up the tree. There he stopped and my attempts to urge him farther, either up or down, failed. Had my marksmanship been more effective it is probable that he would have moved one way or the other. But there I left him. Now it seemed to me that this woodchuck showed rather poor judgment in the first

place. How far he was from his burrow I do not know, but how much easier, and wiser, his modus operandi would have been simply to have slid down the tree to the ground the short distance of the six feet and have made his escape in the underbrush. But that is another matter. Some time later another member of our party also came upon a woodchuck sitting in a pine tree in another locality.—ARTHUR M. JOHNSON, *Minneapolis, Minnesota.*

ANOTHER TREE-CLIMBING WOODCHUCK

During the first week of June, 1924, I came upon a woodchuck sunning itself in the branches of a scrub wild apple tree at Cazenovia, New York. The tree trunk was not more than four inches in diameter, if that much, and the branches were of the sucker sort, thickly interlaced, and growing fairly close to the ground. It would have been possible for the animal to have climbed up without an effort such as would be required for it to go up a clean trunk. At any rate, it was away up among the more slender branches with its weight distributed on them. We annoyed it with sticks and stones until it came down in much the same manner as a dog comes down stairs, sure-footed.—WALLACE HAVELOCK ROBB, *Belleville, Ontario.*

FLYING SQUIRRELS AS CITY NUISANCES

It has become necessary in several cities of the Middle West to wage war on flying squirrels, for in recent years, they have grown so numerous and troublesome as to constitute a civic nuisance. A press notice from Iowa City, Iowa, in the fall of 1924 reported such a condition in that city. At about the same time, the writer was told that flying squirrels were very abundant in Davenport, Iowa; and an investigation showed that this was the case. One mystified resident from Davenport brought a couple of flying squirrels to the writer and desired to know the name of the "funny rats" that had invaded the premises and neighborhood, and that were constantly being brought in by his cat. During October of the present year (1925) flying squirrels have become quite troublesome to residents in the vicinity of Prospect Park at Moline, Illinois. The small, active rodents gain access through windows, crevices under the eaves, and similar apertures to the attics of homes, and here, according to complainers, they make considerable noise at night. At first residents in the neighborhood thought that the night prowlers were rats, but the capture of a few in rat traps brought to light the true identity of the offenders. One citizen caught two during successive nights, but has continued to be annoyed by others which refuse to be caught.—F. M. FRYXELL, *Augustana College, Rock Island, Illinois.*

DRESSED WEIGHTS OF MUSKRATS, BEAVERS AND JACK RABBITS

In an article on muskrat ranching in Louisiana published in the January, 1926, issue of American Forests, on page 27 we find the following statement: "Each animal weighs about three pounds after skinning, so throwing away of the carcasses means a loss of about eighteen million pounds of choice meat a year." The reader of the above statement, particularly if he has skinned and dressed a musk-

rat, is likely to wonder how the scaly tail, the large hind feet, the capacious stomach, the intestines and the head of the muskrat become "choice meat." Perhaps the writer of the article cited overlooked such trifling details.

In order to determine the true dressed weight of certain mammals the present writer has weighed specimens entire in the flesh, and then dressed the animals, removing the skins, heads, feet and internal organs. When a dressed carcass was washed and ready to be cooked, it was weighed again and the dressed weight recorded. The loss occasioned in dressing the animal was found to vary in different groups, but in general the dressed weight is slightly more than half of the entire weight. The following figures are for average specimens in fair flesh, neither excessively fat nor lean.

As regards muskrats David Lantz reported that the average weight of muskrat carcasses sold for meat in the eastern United States is about 1½ pounds. The writer weighed two adult specimens of the pallid muskrat (*Ondatra zibethica pallida*), a small subspecies , and found that the male weighed 603 grams entire and 290 grams when dressed. The female weighed 515 grams entire and 260 grams dressed. Of a pair of adult golden beavers (*Castor canadensis subauratus*) trapped at Snelling, Merced County, California, January 6 and 8, 1923, the male tipped the scales at 47 pounds entire, and had a dressed weight of 30 pounds, while the female weighed 48 pounds entire and dressed 28 pounds. The stomach and contents of the female beaver weighed 500 grams while the stomach of the male weighed 216 grams. Thus the amount of food eaten at a meal influences the dressing loss. Full stomachs mean great losses when animals are dressed.

Of San Joaquin Valley jack rabbit (*Lepus californicus richardsonii*) the writer recently measured and weighed a series of over one hundred on one trip. Ten adult males shot April 15, 1922, near Stratsford, Kings County, California, averaged 4.62 pounds per rabbit, entire. Ten females shot at the same time and locality averaged 6.16 pounds, entire. Allowing for the fact that all the females contained small embryos (less than 1 inch in length) measurements and weights both showed that the females were larger than the males. Fifty-four jack rabbits, twenty-five females and twenty-nine males, shot near this place, when dressed for market, that is, gutted with heads off but skin and feet on, averaged 3.3 pounds per rabbit. It was found that where jack rabbits had been feeding in alfalfa fields for some time they would dress nearly 4 pounds per rabbit, while those that had lived out on the open plains where food is at best scant, would average only a little over 3 pounds when dressed.—Joseph Dixon, *Museum of Vertebrate Zoology, Berkeley, California.*

THE NUMBER OF FORMS OF RECENT MAMMALS

I recently had occasion to make a careful count of a card index to the genera, subgenera, species and subspecies of recent mammals described since Trouessart's Catalogus (1898). I believe that the result may be of general interest, and it is here presented in tabular form.

	NEW GENERA AND SUBGENERA	FOSSIL SPECIES AND SUBSPECIES BELONGING TO LIVING GENERA	LIVING SPECIES AND SUBSPECIES
Monotremata	1		11
Marsupialia	30	3	272
Dermoptera	2		16
Insectivora	34	15	595
Chiroptera	35	10	936
Carnivora	33	57	1,004
Pinnipedia			19
Lemuroidea	1		50
Anthropoidea	14	6	423
Rodentia (Sciurine)	39	20	992
Rodentia (Murine)	149	40	2,181
Rodentia (Miscellaneous)	26	5	400
Lagomorpha	7	8	237
Edentata	5	3	44
Artiodactyla	37	53	785
Perissodactyla	3	30	134
Cetacea	9	3	18
Total	425	262	8,117

This index has been prepared as part of the daily routine of the Division of Mammals, U. S. National Museum, and it gives a fairly complete idea of the systematic work which has been done during the past twenty-six years. No less than 8,117 new forms of living mammals have been described during the period intervening between Trouessart and the beginning of the year 1925. Add to these the 4,423 listed in the Catalogus (by actual count) and we have a total of 12,540, a number which is probably not far from a correct summary of the forms of living mammals known at the end of 1924.—Arthur J. Poole, *U. S. National Museum, Washington, D. C.*

RECENT LITERATURE

Campbell, Charles A. R. BATS, MOSQUITOES, AND DOLLARS. Boston: The Stratford Co. 12 mo., pp. i-viii, 1-262, with unnumbered plates. 1925.

Under this alluring title Dr. Charles A. R. Campbell, of San Antonio, Texas, presents a comprehensive account of his work dealing with bats as agents in mosquito control and in fertilizer production. This work, extending over a period of many years, has been given wide publicity through the general press, and because of its novelty and alleged importance has received considerable attention. The volume is divided into four parts. In part one are discussed four "allegations," stated as follows:

"*Allegation one:*—That the malarial mosquito is one of the greatest enemies of mankind.

Allegation two:—That the bat is one of man's best friends, because it so relentlessly destroys the malarial mosquito, that insect being its natural and principal food.

Allegation three:—That we can build a home for bats in a scientific manner to meet the requirements of their most singular habits, and one which they will inhabit; a home where, being protected from their natural enemies, they will increase in countless numbers and eradicate the malaria in its vicinity.

Allegation four:—That each bat roost, in addition to its great hygienic value is in itself a little gold mine, by reason of the cash obtained from the natural high grade fertilizer, guano, which it will constantly produce."

Parts two to four relate to other methods of mosquito control and to matters not included within the scope of this review. The introduction is by Ernest Thompson Seton.

With allegation No. 1 there can be little or no disagreement. In allegation No. 2, the sweeping assertion that the malarial mosquito is the "natural and principal food" of "the bat" is misleading, as are also the statements without qualification in allegation No. 3. The author mentions the fact that there are thousands of kinds of bats, some of which, he points out, are of no concern for his purpose; but, omitting any reference to geographic range, he says that the species most common is *Nyctinomus mexicanus*. This bat, the species with which he has evidently worked, is currently recognized as *Tadarida mexicana*, but throughout his book he refers to "the bat" tending to give the uninformed the erroneous impression that the food and other habits of most small bats are everywhere the same.

There is no explanation of the fact that the free-tailed bats of the genus *Tadarida*, which occasionally colonize in enormous numbers, are mainly tropical in distribution, and in the United States are limited chiefly to the southern parts of the southern tier of States, occurring sporadically only a short distance farther north, except in California. The author mentions the red bat, to which he erroneously assigns the name "*Nyctinomus novoboracensis*" (= *Nycteris borealis*), and does not consider gregarious, but apparently overlooks a fact of tremendous bearing on his claim, that like this bat most of the species live in colonies numbering comparatively few individuals. It might be added that knowledge of the occurrence

and habits of most bats does not indicate that it would be practicable greatly to increase their numbers artificially.

Under allegation No. 4 there is a discussion of the quantity and value of the bat guano which is annually deposited in certain caves and which may be produced at artificial bat roosts. Doctor Campbell finally succeeded in diverting a large colony of bats to his artificial bat roost at Mitchell Lake, near San Antonio, Texas. Of several other roosts constructed at or near San Antonio none appears to have been occupied. Mention is made of bats occupying artificial roosts at Gulfport, Mississippi, and at Tampa, Florida, and roosts are referred to in Italy, where another species of *Tadarida* approaches its northern limit. No details are given concerning results at any places except at Mitchell Lake. The experiments have been limited apparently to highly gregarious species of *Tadarida*, which, as already indicated, are by no means world-wide in distribution, yet according to the author (p. 125), "What has been accomplished at Mitchell Lake can, with equal facility, be accomplished in any part of the world."

The author is prone to draw many conclusions clearly not based on the application of the scientific method, which should govern in all such work. Much space is devoted to sentiment and fanciful conjecture. As an example of some of his reasoning he says (p. 14), "While we know positively that the nocturnal variety of mosquitoes termed anophelines convey malaria, we are not positive that other varieties do not convey it, so that the geographical range of malaria can be placed on this hemisphere as extending from Alaska to Patagonia."

So many others of the author's conclusions also are apparently so loosely arrived at as strongly to suggest that he may be mistaken in regard to the extent to which *Tadarida* feeds upon *Anopheles*, and in the general rôle of this bat in malaria control. In fact, several entomologists trained to such work who have made examinations of bat feces from the Mitchell Lake roost have found them to contain fragments of various insects likely to be injurious to agricultural crops, but no trace of mosquitoes. These examinations indicated that mosquitoes could not, therefore, have been the "principal" food of the bats, at least at the time the material for study was collected.

In many years of field work within the geographical range of *Tadarida mexicana* in Mexico, including malarial districts in which this species abounded, no evidence that this bat feeds upon mosquitoes came to my attention, and malaria was very prevalent in some sections where the bats found ample cover in the loosely constructed roofs of houses, and in hollow trees, as well as in caves. These bats were sometimes observed in pursuit of larger insects, presumably small moths or beetles.

Doctor Campbell has apparently conducted his work on the relation of bats to mosquitoes with an uncontrolled zeal and enthusiasm that have led him to make sweeping statements, the gross exaggeration of which, it would seem, should be obvious to any scientifically trained worker. Aside from his own allegations the evidence presented is mainly in the form of the testimonials of local residents, few of whom are likely to have had the background of special knowledge, which alone would enable them to render an authoritative opinion. While many bats may be useful insectivorous animals, the conclusions reached in regard to their value in the control of malaria based on such evidence are very unconvincing to those informed. The author has demonstrated that a bat roost with commercial

possibilities as a fertilizer producer may be constructed under especially favorable conditions, but there can be no justification for his assumption that what has been done at Mitchell Lake can be done anywhere in the world, ignoring the distribution of species and environmental conditions in general. The public should be warned that the construction of expensive bat roosts even for guano production, should be undertaken only on the basis of expert knowledge of bats in their relation to local conditions. The unqualified recommendation (pp. 157–158) that every community, large and small, should have one or more of these bat roosts, which may cost from $2,500 to $3,500, would, if followed, mean in most cases a useless expenditure of funds and certain disappointment.

The novelty and plausibility of the bat roost idea as presented are calculated to appeal to the imagination. Unfortunately, the book may be accepted at its face value by many who are unfamiliar with the fundamental biological principles involved and who can ill afford the loss of money invested in bat roosts, most of which, except in localities in certain regions only that are favorable for guano production, are sure to remain permanently empty.—E. A. Goldman.

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